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THE AUGUST SCIENTIFIC MONTHLY

EDITED BY J. MCKEEN CATTELL

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THE SCIENTIFIC MONTHLY

AUGUST, 1931

BIOLOGICAL OPPORTUNITIES IN SIAM

By Professor GORDON ALEXANDER

FORMER VISITING PROFESSOR OF BIOLOGY, CHULALONGKORN UNIVERSITY

IT is a significant commentary on biological opportunities in Siam that, until recently, the only facts the average individual could readily associate with the country were biological. Siam, since the height of Mark Twain's fame, has been the home of the "white" elephant, and that mysterious land from which came the original Siamese Twins. Only in the past few years have increasing ease of travel and moving pictures, as travel substitutes, broadened this viewpoint. Now the layman associates additional and more significant facts with Siam. Politically and socially the country is slowly coming closer to us. Her government is described for us over the radio by His Serene Highness, the Minister from Siam, while we have read in the newspapers of the visit of Their Majesties to the United States. Our original picture is fading in favor of a saner and fairer one. We have all thought that Siam must be, for the most part, a hinterland of dark jungle, inhabited largely by elephants and tigers and apes, where man exists only through a supreme but very close-to-nature cunning! Our imagination has been extravagant. Siam is not a savage land. This does not mean, however, that she is not and will not be for years to come a land of opportunity for the biologist.

The biologist's interest in Siam to-day is other than in the Siamese Twins, who passed away in 1874, or in the two, present-day, albino elephants housed in the stables at Dusit Park. It is in her rich fauna and flora. The fauna and flora, rich as they are, are still in many respects virgin to scientific investigation. Siam is not all jungle, and most parts are far more readily accessible than one imagines, but many of her groups of animals and plants have hardly been studied even by the field man—usually forerunner of all the rest. If there yet remain any of the admirable group described as "naturalists," Siam is still their happy hunting ground.

Not the least of the factors making for increased opportunity in Siam to-day is improved methods of transportation. The days of weary tramping through "untracked jungle," week on end, are about ended in Siam. Modern transportation is so rapidly coming to man's assistance that there is no longer the former great difficulty in reaching out-of-the-way sections of the kingdom. From Padang Besar, on the border of Kedah, to Chiengsen Kao, on the Mekong, almost a thousand miles away in a direct line, and in the east and northeast to Nong Kai or Ubon, are connecting railways or roads. My wife and I traveled from Padang Besar to Chiengsen Kao, some twelve hundred miles by rail and road, in less than three days actual traveling time. Twenty years ago it might have taken as many months. Padang Besar is on the south-

THE MEKONG AT CHIENGSEN KAO

A MAGNIFICENT RIVER, EVEN HERE, 1,500 MILES FROM ITS MOUTH.

ern boundary of peninsular Siam, Chiengsen Kao is almost the farthest north point of Siam. Even Nan, where the movie "Chang" was filmed several years ago, we were able to visit by motor car. A dry-weather road was opened in February, 1930, from the nearest railway point, some eighty miles to the southwest.

Along the coasts of the Gulf, one can easily make arrangements to be landed at desired points on the mainland or islands from one of the several comfortable steam or motor ships of the Siam Steam Navigation Company. In this way the writer and Nai Siri Habananda, also of the department of biology of Chulalongkorn University, were able to spend several days with Dr. A. S. Pearse in observation on Koh Chang, the largest Siamese island in the eastern portion of the Gulf.

In addition, there is the air. Siam is not backward in aviation, for she has her own aeroplane factory and manufactures some fifty planes each year. Some foreign visitors have already used aeroplanes to reach certain outlying dis-

THE MENAM MEKOK AT CHIENGRAI

A TRIBUTARY OF THE MEKONG. THE RAFTS IN THE FOREGROUND ARE OF BAMBOO, A MOST VERSATILE WOOD AS USED BY THE SIAMESE.

THE RICE PLAIN OF NAN

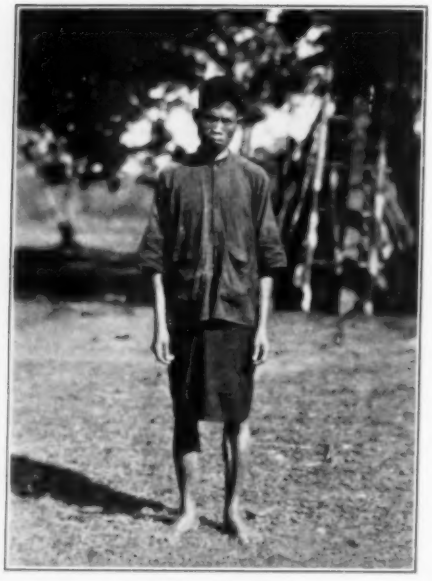
THE PLAIN OF THE NAN RIVER, NORTHERN SIAM, SUPPORTS A CONSIDERABLE POPULATION.

tricts, but the cooperation of the government is necessary. Where modern transportation fails, and that is usually relatively near one's destination, one simply resorts to the only methods of the past, travel on foot or on horseback or in dugouts. Reliable and peaceful local carriers or polers are available. However, it is a great advantage that most of the sections one wishes to visit are readily accessible by modern, rapid means of transportation; but the improvements in transportation will, one may be sure, rapidly bring about changes in the natural conditions themselves. This change has, in fact, already begun.

The visitor in Bangkok may be surprised to find that his English is quite sufficient, providing he adapts it to his audience, and forgets any native pigheadedness he may possess. This is not

THE NAN RIVER AT NAN

THE RIVER MAY BE FORDED ON FOOT DURING THE DRY SEASON, AT WHICH TIME THIS PHOTOGRAPH WAS TAKEN.



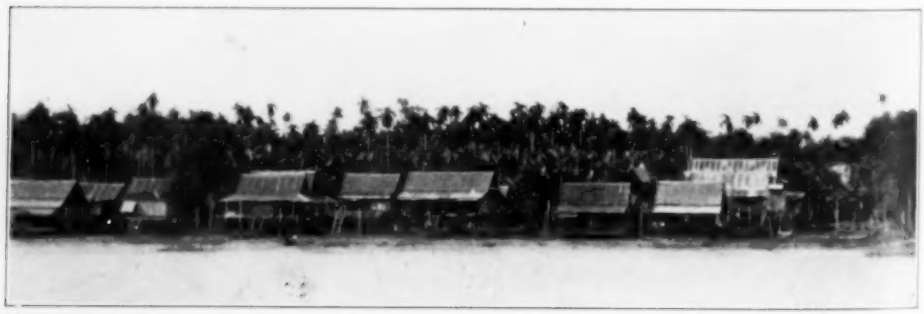
A LAO OF NAN

THIS MAN ASSISTED ME IN SKINNING BIRDS, DURING OUR WEEK IN NAN.

so true in the back country. The Siamese who speak English, even of the official class, are relatively less numerous outside Bangkok. The atmosphere of the capital city is more cosmopolitan; that of the countryside, distinctly Siamese. The traveler in the interior of Siam should have an interpreter, unless he himself can speak Siamese in some form, and with considerable ease. One could, perhaps, but not to such advantage, substitute one of the principal dialects of southern China. Certain forms of Chinese are widely spoken in Siam by natives of southern China, who, after having emigrated there, have penetrated to even the most remote jungle villages. On the other hand, inability to speak the language of the Siamese does not make life with them the more unpleasant. They are an exceedingly polite people. The bond of sympathy which comes from ordinary good nature, good humor and the use of the universal sign language is quickly established.

Some months ago an incident occurred which demonstrated this in a forceful way. A young English girl, through some unknown cause, fell from the window of her railway compartment in the International Express from Singapore to Bangkok. The accident occurred at night, and she was not missed by her parents until the next morning, still a half-day south of Bangkok. When the frantic father found her that evening, many miles to the south, through the telegraphic inquiries of the railway officials and special transportation which they provided, she had been fed and taken care of by some Siamese farmers who had found her, and except for a shaking up and a cut where she was injured in falling, she was perfectly safe. She had known not a word of Siamese, but had experienced the boasted hospitality of the Siamese peasant.

The visitor has little occasion to fear



THE BANK OF THE MENAM CHAO P'YA BELOW BANGKOK

NIPA, ARECA AND A FEW COCONUT PALMS MAY BE RECOGNIZED. THE OTHER TREES ATE MANGROVES.

THE SCIENCE BUILDING, CHULALONGKORN UNIVERSITY

SIAMESE UNIVERSITY STUDENTS

THE BIRDS ARE GIANT HORNBILLS

These specimens of *Dichoceros bicornis* (L.) were taken on Koh Chang, a large island in the Gulf of Siam. The man wearing the beret is Nai Siri Habanananda, a biologist of Chulalongkorn University.

for his safety in Siam. I think we are less safe, in many ways, in America. Certain types of disease must be continually guarded against, but, through eternal vigilance, the danger from these is greatly lessened. The chief "racketeers" are still political grafters, and there are plenty of such, even in an absolute monarchy! The animals that may harm man are not abundant, and the very conditions that are associated with improved methods of transportation have made for their reduction. The one hundred per cent. conservationist regrets this, but the residents of a village in which as many as twenty human beings have been killed by tigers in a single year do not. And these native villagers are generally without fear, according to our standards.

Of immeasurable assistance to all foreign visitors in the interior, and always to be considered in one's plans, are the missionaries. Many isolated sections are perfectly familiar to representatives of one of the mission organizations, and these men are often extremely generous in their assistance of field biologists. Of these groups, of chief importance and largest in point of numbers, is that composed of the members of the American Presbyterian Mission. These are concentrated in northern Siam, but there are a few representatives also in the peninsular portion of the country. It was the privilege of my wife and me to spend some three weeks in February and March in northern Siam. We visited Chiengrai, Chiengsen, Chiengmai, Nan and Prae, and in every place enjoyed the hospitality of American missionaries who were active in helping us secure information, photographs or specimens which we wished. The missionaries usually enjoy contacts with outsiders, but the obligation is certainly not theirs. Why a "professional" traveler should

A LAO HOME

A few miles northwest of Chiengrai.

IN THE MOUNTAINS NORTHWEST OF CHIENGRAI

EVERGREEN FOREST OCCURS IN PARTS OF NORTHERN SIAM. THIS PHOTOGRAPH WAS TAKEN AT AN ELEVATION OF ABOUT 1,500 FEET.

expect to express his whole thanks in terms of an autographed copy of his latest book, or a water-color sketch of the banana trees in one's compound, as some do the world around, is unaccountable. The comforts of life he has enjoyed are so inaccessible to his host that the latter, who may live five hundred miles from his nearest "American" grocery store, is considerably out of pocket and larder. I think the visiting scientist at least recognizes his obligation, for nearly every report of scientific collections in northern Siam includes acknowledgments to members of the missionary group.

One may gather from the above remarks that Siam is much more accessible than the work of field biologists up to date would indicate. This, in fact, is true. The fauna, as a whole, has not yet been well collected. The more primitive phyla are hardly known. No more than introductory studies have been made on the plankton, either fresh-water or marine. Little actually is known of the variety of invertebrates in the Gulf of Siam. More is known of the larger, fresh-water invertebrates, but the incomplete studies of a few groups have already yielded such a variety of forms that it is obvious that these very studies have not been exhaustive. For example, a paper appears on the river crabs of Siam. Several new varieties are described, these of very limited distribution—the streams of one small mountain, say. Yet extensive portions of the country are not represented in the collections studied, and one can only guess that higher and more inaccessible mountains somewhere else, unvisited, may yield still other forms.

Dr. Hugh M. Smith has collected more than fifty species of shrimps of commercial value in Siam; and has said that it "seems altogether probable that in no other country do shrimps exist in greater profusion."[1] An unbelievable

[1] Hugh McCormick Smith, "A Review of the Aquatic Resources and Fisheries of Siam, with Plans and Recommendations for Their Administration, Conservation, and Development." Bangkok: Ministry of Lands and Agriculture, 1925.

A PALM GROVE ON KOH CHANG

Draco WAS NUMEROUS IN THIS GROVE, AND DR. PEARSE COLLECTED ONE SPECIMEN OF *Ptychozoon*.

A MALAY FISHING VILLAGE IN THE INLAND SEA

MALAYS BECOME VERY NUMEROUS AS ONE APPROACHES THE SOUTHERN BORDER OF SIAM.

variety of these crustaceans has been reported from the Inland Sea alone, a body of water in peninsular Siam, about sixty miles long, and having a marked gradient of salinity from its brackish southern end to the fresh water of the northern end. No one has yet properly taken advantage of the possibility here to study the influence of this interesting saline gradient in the distribution of life in the Inland Sea, whose fauna is remarkable in many other ways than in the abundance and variety of shrimps. But, naturally, little ecological study can be accomplished until the fauna itself is better known. Certainly, present work on invertebrates can not be considered "monographic," especially since the fauna of Bangkok itself is comparatively unknown.

It is quite apropos, in this connection, to refer to the recent remarks of two American scientists in the Orient[2] re-

[2] G. E. Gates, *Science*, 70: 266–267, September 13, 1929; A. P. Jacot, *Ibid.*, 73: 11–12, January 2, 1931.

COCONUT PALMS ON AN ISLAND IN THE INLAND SEA

A MOTOR SHIP OF THE SIAM STEAM NAVIGATION COMPANY
THIS VESEEL IS AT THE PIER IN THE CHANTABOON RIVER, SOUTHEASTERN SIAM.

garding the ease with which we overlook our fauna. It is not an accident that both of these men happen to be students of an exotic fauna. Their eyes have been sharpened through a taxonomic exercise the average biologist does not get. If our fauna is so little known—and how can it be otherwise in the present feverishly experimental cycle?—how much less known is the fauna of a country where biological students have always been rare? Perhaps the Siamese will not put the cart before the horse, and will, to take a simple example, really find out what *Euglena viridis* Ehrbg. looks like before experimenting with another species of Euglena under the impression that it is the old tried-and-true form pictured in all the text-books! It is to be feared, however, that our bent for experimenting with organisms of whose names, even, we are ignorant, is being rapidly communicated to them.

If there is any group of Siamese invertebrates fairly well known it is that which includes the butterflies. Over seven hundred forms have been identified, and a list of these has but recently appeared.[3] The moths, however, are not so thoroughly known. In a collec-

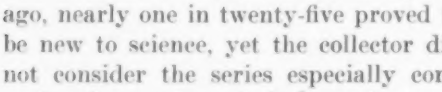
[3] E. J. Godfrey, "A Revised List of Siamese Butterflies," *Jour. Siam Society*, Natural History Supplement, 7: 203–397, 1930.

THE INLAND SEA FROM THE SOUTH
THIS PHOTOGRAPH, TAKEN FROM A SMALL HILL, LOOKS ACROSS THE CITY OF SINGORA, WHICH IS CONCEALED BY THE TREES.

ON THE CHANTABOON RIVER, SOUTHEASTERN SIAM

THE CROWD AND SHORE, PHOTOGRAPHED FROM THE DECK OF A COASTWISE SHIP.

tion of nearly four hundred species sent to the British Museum several years ago, nearly one in twenty-five proved to be new to science, yet the collector did not consider the series especially comprehensive. (One of the most interesting Siamese moths to the casual visitor is the giant Atlas moth so often figured in books on natural history. It is not infrequently seen in Bangkok.) The writer made a small collection of ants from various parts of Siam, and, although only "scratching the surface," this collection contained four forms new to science. Collections of a few other groups of insects have been made, but the insects in general are a closed book, and this statement applies in particular and with special interest to one of the largest and most widely distributed groups of insects, the beetles. It is remarkable that a group as large as this, and so spectacular in many ways, should have been practically neglected. Everywhere, in new countries, the spectacular seems to attract the collector's attention. The vertebrates and, among the invertebrates, the lepidoptera and coleoptera usually come in for early attention. They are showy. Other groups are neglected almost in inverse ratio to their showiness.



A SPECIES OF *OCYPODE* AT ITS BURROW ENTRANCE

THIS FORM WAS COMMON ON THE BEACH AT HUA HIN.

The tourist at his first evening meal in Bangkok is made thoroughly aware of the wealth of insect life. A host of night-flying forms hover above the table, about the lights, or occasionally

MALAYAN TAPIR

THIS ANIMAL CONSTITUTED PART OF A SMALL ZOO MAINTAINED BY THE GOVERNOR OF SINGORA.

drop into his plate or drinking glass. These are almost ignored, however, for the bane of Bangkok in the evening is the mosquitoes. Malaria is rare in Bangkok, fortunately, though not elsewhere in Siam, but the capital seems to lead the country in mosquito as well as human population. The foreign residents protect their ankles with mosquito-boots, "mosquito-bags"—made of sarongs, splash themselves with some of the several anti-mosquito concoctions, or, better still, spend the evening in rooms which have been screened against mosquitoes. A comfortable evening in Bangkok is often only possible in one of the latter. One never thinks of sleeping outside a mosquito-net. Other insects are just as numerous, though not so annoying. Of special interest to the biologist are the aggressive, red tree-ants of the genus *Œcophylla*, which are everywhere. On one small pomelo tree in our compound there were a half-dozen large nests. Their exhibitions of muscularity in pulling together the leaves of the nest are marvelous, and, even among ants, it must be fairly novel to employ one's larvae as mucilage-tubes!

These are all free-living organisms. But there is another fauna, concealed, almost unknown the world over, about which still less is known in Siam. The parasites of a free-living fauna so little known are least known of all.

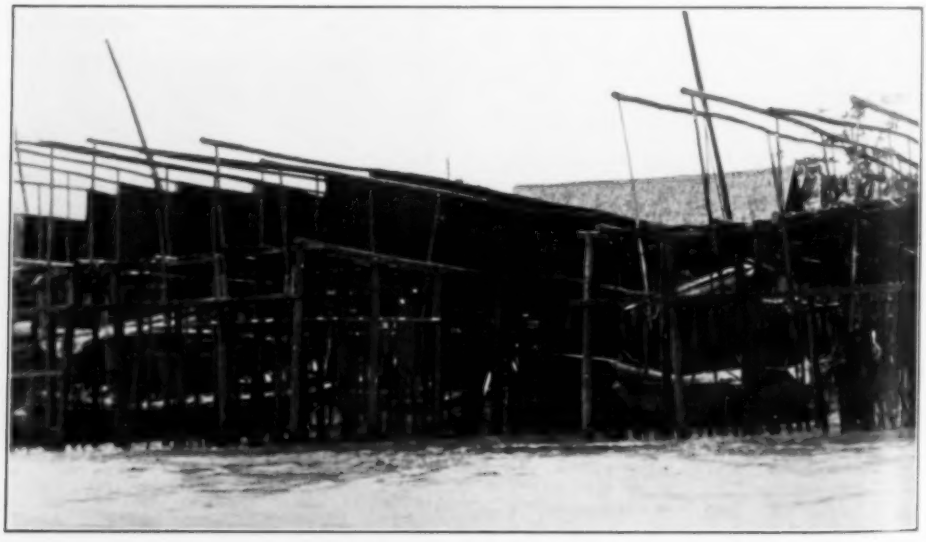
The vertebrates have received more attention. All groups have now been studied to a greater or lesser extent—the fishes by Dr. Hugh M. Smith, the amphibians and reptiles by Dr. Malcolm Smith, birds and mammals by eight or ten recent students. But even in groups as thoroughly investigated over a considerable period of time as have been the reptiles and birds, new species are still being discovered by the few collectors, and Dr. Hugh M. Smith assured me that he believed he would continue to find new species of fish every year as long as he remained in Siam. These new species are not necessarily rare species. Further than the taxonomic studies, a beginning has been made in studies of life histories, distribution, food habits, but in general the biology of Siamese vertebrates is little known.

The abundance of life, especially the number of varieties of organisms, is

A NEST OF *OECOPHYLLA*

FISHERMEN TAKING IN A NET

astonishing. The density of variation, if one may be permitted to use such an expression, is much greater in Siam than in the United States, in spite of the fact that our country shows greater climatic and topographic differences. Siam is entirely within the tropics, and temperature differences between different sections of the country are not great. No high mountain ranges act as effective barriers in definitely setting off particular zoological regions. Those



FISH NETS DRYING

At Paknam, on the Menam Chao P'ya, below Bangkok.

VULTURES AT A FEAST
THE SPECIES IS *Pseudogyps bengalensis (Gmel.)*

regions thus far postulated for Siam have merely been suggestive, and there is little to indicate that *marked* faunal or floral differences should exist between different regions within the country. Nevertheless, considering Siam as a whole, its variety of life is truly enormous.

In the *klongs*, or canals, of Bangkok there seems an inexhaustible supply of fishes. These are of many species. In a disused canal along one side of our compound, which had grown up heavily in water plants, rooted and floating, I collected a dozen species of fish in a space fifty feet long. The canal was some twelve feet wide and about two feet deep at the deepest. It is not unusual to see Siamese fishing with hook and line, and catching fish, in a canal that one can jump across; but, in spite of their continuous fishing, even with nets, the supply seems to keep up with the demand.

THE ROOT SYSTEM OF *PISTIA*

FISHERMAN WITH HIS CATCH
FROM THE INLAND SEA.

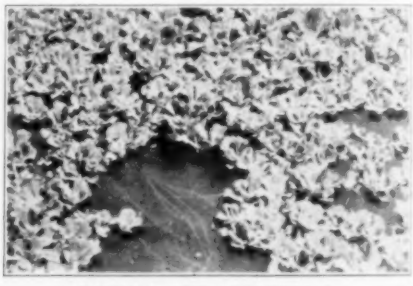
SPINIFEX

A DIOECIOUS GRASS, REMARKABLY ADAPTED FOR WIND DISSEMINATION, COMMON ON THE BEACH AT HUA HIN.

EICHHORNIA SPECIOSA KUNTH.

THE WATER HYACINTH, A NATIVE OF AMERICA, HAS BECOME SO ABUNDANT IN MANY RIVERS OF SOUTHERN ASIA AS TO BE A HINDRANCE TO NAVIGATION.

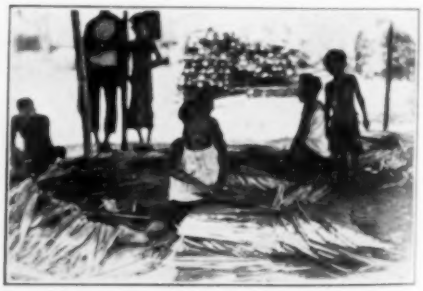
TRACKS IN THE MUD, MADE BY GOBIES



PISTIA STRATIOTES L.

THIS PLANT IS SAID TO BE MUCH LESS COMMON THAN FORMERLY, ITS PLACE BEING USURPED BY THE WATER HYACINTH.

NIPA FRUTICANS THUNB.



MAKING THATCH FROM LEAVES OF THE NIPA PALM

In area Siam is a little smaller than the state of Texas, but already the check-list of bird species from the kingdom is almost as long as that of the American Ornithologists' Union. It may prove to be longer. Already more genera and families of birds have been recorded from Siam than from North America north of Mexico. As striking evidence of the abundance of birds one might be referred to the report of de Schauensee's recent collections[4] made in northern Siam. In a period of about seven weeks (in December and January), with local collectors, he was able to secure representatives of over two hundred species. The collecting localities were hardly farther apart than New York and Philadelphia, and with a difference in elevation of but four thousand five hundred feet. Northern Siam and the neighboring countries constitute one of the most interesting sections of Asia for the ornithologist.

[4] R. M. de Schauensee, "A Further Collection of Birds from Siam," Proc. Acad. Nat. Sci. Phila., 81: 523–588, 1929.

WINDOW SHOPPING IN HUA HIN

Such collections really indicate a rich bird fauna, and are not made up of a large percentage of rarities. The following results of a twenty-five minute morning bird census, taken from a moving train between Bangkok and Ratburi, serve to illustrate this fact. In this brief April census, 108 individuals were observed, representing at least twenty distinct species, of fifteen different families that could be readily recognized. Fifteen families of birds in

CASUARINA TREES AT SINGORA

This tree is planted in Bangkok for ornamental purposes, but nowhere did we see it so well established as on the beach at Singora.

A GOBY ON A MUD-FLAT

This individual, which was about eight inches long, belongs to a species of *Periophthalmus*.

THE MENAM CHAO P'YA AT LOW TIDE
GOBIES ARE NUMEROUS ON SUCH MUDFLATS AS THIS.

twenty-five minutes of observation is certainly indicative of variety. In the same month, at Hua Hin, in peninsular Siam, Mrs. Alexander and I recorded over forty species of birds in a walk from six to eleven A. M. Such a list can not be compared with an April list in New Jersey, which should be much longer, of course, but April in Siam is the hottest and driest month of the year. Hence, in this short trip on foot, we observed over forty presumably resident species.

Certain groups of animals, which seem to illustrate definite evolutionary trends, are of special interest. The vertebrates, other than birds, that have essayed flight are well represented. In the Gulf are flying fishes; in the cocoanut groves occur several species of the "flying dragon," *Draco*, and also *Ptychozoon*, the gecko which probably does not fly—contrary to early opinion. The former has excited interest from the earliest reports of its existence. I have seen a fair representation of it in a book published as early as 1686.[5] Flying squirrels of several species, some quite large, occur, as also the large insectivore, the so-called flying lemur. Bats, both frugivorous and insectivorous, are abundant. "Flying foxes," of the genus *Pteropus*, are very common.

A similar behavior group is constituted by the fishes that show various adaptations toward air-breathing. These vary in "success" from a type like *Trichogaster*, which has an accessory breathing organ, but is so flattened laterally that it is incapable of progressing out of water, through *Clarias*, *Ophiocephalus*, and the so-called climbing perch to the beach-skipping gobies.

[5] O. Jacobaeus, "O. Jacobaei de Ranis et Lacertis observationes." Hafniae. [xiv] + 144 pp., 1686.

The latter remain out of water for long periods, and actively and swiftly move along the mud-flats, pulling themselves by the pectoral fins. Altogether about twenty species, perhaps more, of fish variously modified for air breathing are found in the canals and the river near Bangkok. During May and June, 1930, Dr. A. S. Pearse studied these types in Bangkok with reference to the general problem of the migration of organisms from sea and fresh water to land. The results of his studies will indicate in part the opportunity in Siam for observation on what still remains the greatest problem in biology—the origin of adaptation, the origin of species.

With the flora as with the fauna, the striking forms have received the chief attention. The cryptogams have been largely neglected. But even with the flowering plants, the botanist's task is a long one. Dr. A. F. G. Kerr, who has collected plants more extensively in Siam than, perhaps, any other individual, estimates the flowering plants of Siam at 10,000 species. The Florae

NELUMBIUM SPECIOSUM WILLD.
THE SACRED LOTUS IS WIDELY CULTIVATED IN SIAM.

RAIN FOREST ON KOH CHANG
THIS ISLAND, IN THE EASTERN PART OF THE GULF OF SIAM, IS IN ONE OF THE HEAVY RAIN BELTS.

Siamensis Enumeratio of Craib, now appearing in parts, as issued by the Siam Society, will summarize the present knowledge of Siamese flowering plants. Of the species thus far collected, about 20 per cent. are endemic. Wherever foreign contact has come, foreign types have been introduced. In Bangkok nearly 30 per cent. of the flora is introduced; and it is interesting that tropical America, including the West Indies, has supplied more than one third of the introduced species. The problem of the flora is no easier than that of the fauna, and offers a long future of useful study. If we should attempt to summarize in broad fashion the present position of the biology of Siam we should be compelled to say that a very small fraction of the fauna and flora is known even by name, and that little but little more than by name.

The country itself, though ranging

THE PLOUGHING CEREMONY

A ROYAL CEREMONY AT BANGKOK INITIATES THE RICE PLANTING SEASON.

through sixteen degrees of latitude, does not show a wide variation in temperature. There is, however, considerable variation in rainfall between different sections, largely due to the location of mountain ranges in relation to moisture-laden winds. Most of the rain comes from the southwest. The heaviest rainfall, therefore, is along Siam's portion of the west coast of the peninsula. The mountains along the boundary between Burma and Siam are such an effective barrier that the rainfall on their western slopes is three times as heavy as that which reaches the plains of central Siam. Another region of heavy rainfall lies along the east coast of the Gulf of Siam. Here also, as along the west coast of

REMOVING RICE PLANTS FROM THE SEED PLOT

THREE OF THE PLOTS IN THE BACKGROUND HAVE BEEN SET OUT, WHILE ONE IS READY FOR THE SEEDLINGS.

ELEPHANT ROLLING TEAK LOGS INTO THE YOM RIVER

peninsular Siam, one finds the so-called tropical rain forest, a rather heavy evergreen forest in which epiphytes and climbing plants are especially abundant. But, although most of the rest of Siam is forested, none of this area is so luxurious, and much of it is open and deciduous. Over most of Siam there prevails alternate rainy and dry seasons, and the annual rainfall may be only forty or fifty inches; in fact, in some sections it is less even than that. It is, then, manifestly incorrect to indicate heavy rain forest all over Siam in phytogeographical maps. Further, a considerable area is unforested. Most of the plain of the Menam Chao P'ya, the great central river of Siam, is an unforested rice plain. Siam is more than half forested, but only small sections of this are as heavily forested as much of Burma to the west or Malaya to the south.

The Siamese people are agricultural. Since they first began to filter into their present territory from the north, a thousand years ago, they have concentrated themselves in the broad river plains which could best be adapted to rice culture. In the north, where the land is mostly hilly, these rice plains are rather accurately defined. In each such plain, between the more or less parallel, north-and-south ranges of hills, are concentrations of people, *e.g.*, at Chiengmai, Lampang and Nan. But, naturally, the greatest concentration of population to-day is in the valley of the Menam Chao P'ya. (Menam is Siamese for "river"; which means that the usual map designation, *Menam River*, is ambiguous.) The plain of this river extends north from the mouth two hundred miles, varying in width from forty to one hundred miles. The delta proper is nearly a hundred miles long. Bangkok, with other lesser cities, is located in the delta. The rice growers around Bangkok are almost as dependent on the annual inundations of the Chao P'ya as are the Egyptians on the overflow of the Nile. Artificial irrigation is known and widely practiced, but the chief advantage of the annual overflow is, apparently, in the renewing of the soil, obviating the necessity of fertilizing.

Agriculture furnishes the key to the chief expansion of biology in Siam, but the possibility of scientific improvement of agriculture has really not become a

TEAK LOGS IN THE MENAM YOM AT PRAE

AT THIS TIME LOGS WERE BEING COLLECTED IN THE RIVER AWAITING FLOOD WATER.

part of the "social consciousness." The division of the government concerned with agriculture should be one of its strongest departments. Actually, it is one of the weakest. Only in the Department of Fisheries, through the organizing activity of Dr. Hugh M. Smith, has any considerable progress been made. This is not insignificant, however, as, next to rice, fish constitutes the most important element of the Siamese diet. The value of the annual catch has been estimated at twenty-five million ticals,[6] or about twelve million dollars; and only about 12 to 15 per cent. of this catch is exported. Forestry conservation, representing a third field for the application of biology, has been practiced for some time, though limited to the more valuable timbers, *e.g.*, teak. Proper integration of these three fields of official effort and the department of biology of Chulalongkorn University (the only university in Siam) will increase enormously the field of service of the latter, and improve the efficiency of the former.

At present, biology instruction in Siam is practically limited to pre-medical students. Largely through the cooperation of the Rockefeller Foundation in pre-medical education, in connection with the medical program, the departments of biology, chemistry and physics have been firmly established. Training in the latter two sciences is required of engineering students, but training men locally for the fisheries, forestry and agriculture has not been practiced—at least of those men who are expected to have positions of governmental responsibility. Local training of men for the fisheries has, however, been suggested. There is a move on foot now, following the natural evolution of the university, to provide for four years' instruction in biology. The present pre-medical curriculum is for only two years. The benefits of such a plan must necessarily involve the correlation of various fields of applied biology in the educational system. But more than that, it should mean the establishment of a nucleus of Siamese investigators who can exploit properly the scientific as well as economic resources of the fauna and flora of their country. Only then can the biological opportunities of Siam be fully realized.

[6] H. M. Smith, *Ibid.*

DEVELOPMENT OF THE EGG FROM THE STANDPOINT OF THE GENETICIST[1]

By Dr. C. W. METZ

DEPARTMENT OF GENETICS, CARNEGIE INSTITUTION OF WASHINGTON, COLD SPRING HARBOR, N. Y.

In the two preceding papers of this series[2] the development of the egg has been considered from the standpoint of the embryologist and the physiologist, respectively, in accounts which dealt especially with the human egg or with the eggs of mammals closely related to man, and stressed particularly those aspects which obviously have direct bearing on human development. In the present account attention is invited to another aspect of development, or rather to some more general aspects of development. At first sight many of the features discussed here may seem to have little relation to man, but in the long run they will, I believe, lead to conclusions bearing as directly on human development as on that of the other animals whose characteristics or behavior they reflect.

Like most other fields of biology, the study of development requires experiments; and since man is one of the most unsatisfactory animals for experimental purposes students concerned with the fundamental aspects of development, without special regard for immediate human problems, have avoided man for the most part and have confined their attention to the lower animals. It is studies in this latter field which I wish particularly to consider.

If we look back about thirty-five years in the history of biology we find that the development of the egg, considered from this general point of view, was receiving the concentrated attention of many of the leading biologists of the world. The work of these men marks an epoch in biological advance, and we can do no better, I believe, in approaching the subject of development than to begin with a consideration of their period.

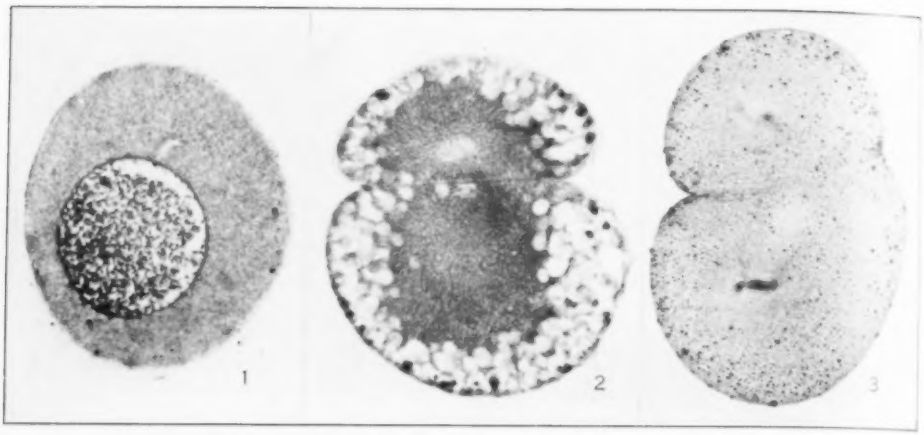
The actual studies carried on at this time involved eggs of all sorts, from the minute free eggs of the sea-urchin and starfish to the large enclosed eggs of the frog and chick. These eggs were observed as they developed under ordinary normal conditions, and observed as they developed under various unusual or artificial conditions, such as followed, for instance, from treatment with heat, cold, various chemical agents, pressure, radiation, etc. They were also cut up into fragments and the behavior of the fragments studied, and they were whirled rapidly in the centrifuge to force their internal components into different relations to one another, to see what effect this would have on development. In fact a multitude of different experiments were carried out.

The purpose of all these was not simply to see in what manner the eggs developed. That could be determined by direct observation in most cases. It was to learn *why* the different kinds of eggs developed as they did; why one kind of egg developed in a particular way and gave rise to one kind of animal, while another kind of egg under the same conditions developed in a different way and gave rise to another kind of animal.

More specifically the design was to find out two things: first, what it is in the egg which controls the developmental processes, and second, how this agency functions. In other words, is it

[1] From a symposium on development given at the Carnegie Institution in Washington in November, 1930.

[2] See papers by Dr. Streeter and by Dr. Hartman in the two preceding numbers of this journal.



FIGS. 1–3. PHOTOGRAPHS OF SINGLE AND DIVIDING EGGS.[3]

FIG. 1. STARFISH EGG BEFORE DIVISION. FIG. 2. EGG OF THE MARINE WORM, *Nereis*, AFTER THE FIRST CLEAVAGE. FIG. 3. WHITEFISH EGG, TWO CELL STAGE, IN PREPARATION FOR SECOND CLEAVAGE. FIGURES ALL FROM FIXED AND SECTIONED MATERIAL.

a general property of the whole egg which determines how that egg is going to develop and what it is going to become; or is this determining function limited primarily to a certain part, or parts, and in either case what is the method of procedure involved?

Space will not permit going into the details of the various experiments carried out during this period, but we may note a few general features which stand out prominently in the work. In the first place it immediately became clear, if it was not already so, that the egg of each different kind of animal has certain definite potentialities. For example, a frog's egg produces a frog—and a frog of a certain definite species—nothing else. The egg may be injured so it will not develop, or it may be made to develop into a deformed or abnormal frog, but, no matter how it is treated, what it finally becomes must lie within the definite range of potentialities inherent in the egg before development began.

Thus the first question to be answered was: what is it in the egg which determines these potentialities? In considering this question we must turn attention to some of the actual processes of development. Ordinarily these involve two separate things: on the one hand, the *growth* of the embryo, and on the other hand, its *differentiation* into different parts. It is through these two processes that the small and relatively simple egg becomes the large and relatively complex animal.

The first step in development is the division of the egg. To begin with, the egg is a single cell, as seen in the accompanying photograph of a starfish egg (Fig. 1). Then it divides into two cells (Figs. 2 and 3) as Dr. Streeter pointed out in the first article of this series, and these in turn into four, and so on until, in most cases, millions of cells are present. Each of these cells has a definite structure—a structure which follows a common general plan in practically all cases, not only within one animal, but throughout the whole animal and plant kingdoms. The superficial features of this plan are shown in the accompanying photograph of living cells (Fig. 4) taken with the aid of ultra-violet light, which reveals the structures better than does visible light. For this and the other

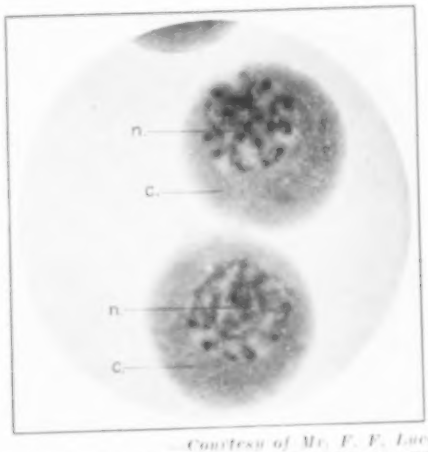
[3] Photographs not otherwise accredited are original.

ultra-violet photograph used here (Fig. 15) I am indebted to Mr. F. F. Lucas, of the Bell Telephone Research Laboratories.

The two most conspicuous regions of the cell are the nucleus (n) seen near the center, and the material surrounding it (called the cytoplasm) which goes to make up the rest of the cell. Both the nucleus and the cytoplasm, in turn, contain other differentiated structures, but for the moment these may be left out of account.

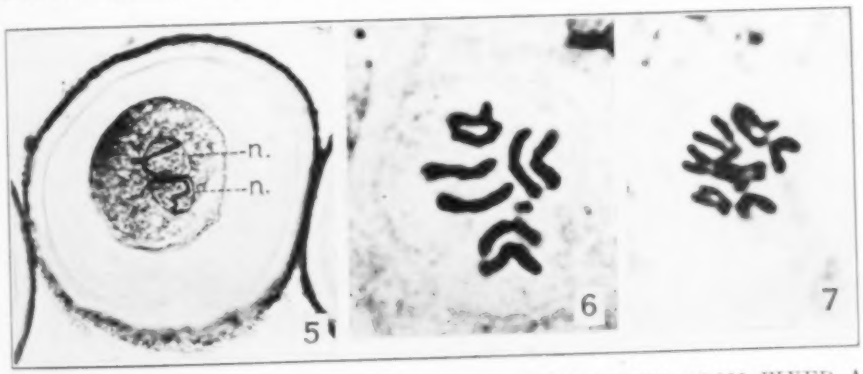
One of the first results of the experiments under consideration was the demonstration that the nucleus is essential for development. It was found that when an egg cell was cut in two, leaving the nucleus in one half, that half could develop into an embryo, but the half lacking a nucleus could not. Even if the nucleus was cut off almost alone, as could be done in some cases, leaving the egg nearly entire, still the egg would not develop without the nucleus. From such experiments it was concluded that development must be greatly influenced by something in the nucleus.

This conclusion, in turn, led to additional experiments; and in considering these it is necessary to go still further back in the life of the egg to the process which, in most animals, really initiates development—that is, the fertilization of the egg by the sperm. The study of the sperm and of fertilization soon revealed another fact of special significance, namely, that the sperm, or the part of it which enters the egg and takes part in later development, is extremely small, as compared with the egg, and apparently consists mainly of nucleus. This obser-



Courtesy of Mr. F. F. Lucas.

FIG. 4. ULTRA-VIOLET PHOTOGRAPH OF LIVING CELLS OF GRASSHOPPER.
n, NUCLEUS; *c*, CYTOPLASM.



FIGS. 5–7. PHOTOGRAPHS OF NUCLEI AND CHROMOSOMES FROM FIXED AND STAINED PREPARATIONS.

FIG. 5. EGG OF A THREAD WORM, *Ascaris megalocephala* VAR. *univalens*, SHOWING THE EGG NUCLEUS (n) AND SPERM NUCLEUS (n) UNITING AT FERTILIZATION. EACH CONTAINS A SINGLE LONG CHROMOSOME. FIG. 6. CHROMOSOMES OF THE ROBBER FLY, *Dasyllis*, FROM A SPERMATOGONIAL CELL. THE SINGLE SMALL CHROMOSOME IS THE UNPAIRED SEX CHROMOSOME. FIG. 7. CHROMOSOMES OF THE COMMON HOUSE FLY, *Musca domestica*, FROM AN OVARIAN CELL.

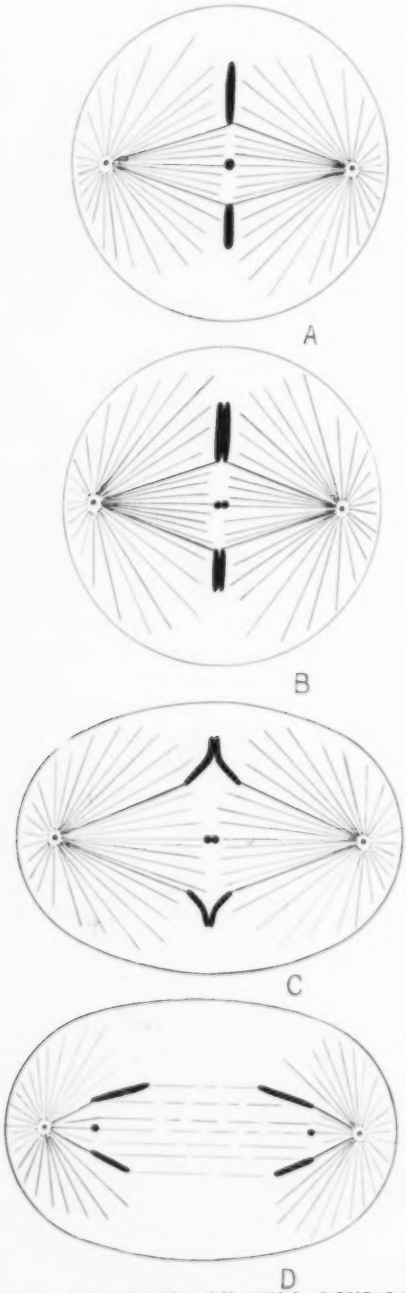


FIG. 8. DIAGRAMS OF CELL DIVISION, OR MITOSIS, SHOWING MOVEMENT OF THE CHROMOSOMES.

A. METAPHASE, BEFORE THE DIVISION OF THE CHROMOSOMES IS EVIDENT. (ACTUALLY DIVISION OCCURS BEFORE THIS STAGE, BUT IT IS NOT ALWAYS EVIDENT.) *B*. LATER METAPHASE SHOWING DUALITY OF THE CHROMOSOMES. *C*. EARLY ANAPHASE, SHOWING SEPARATION OF THE DAUGHTER HALVES. *D*. LATE ANAPHASE, AFTER DAUGHTER HALVES HAVE PASSED TOWARD THE POLES.

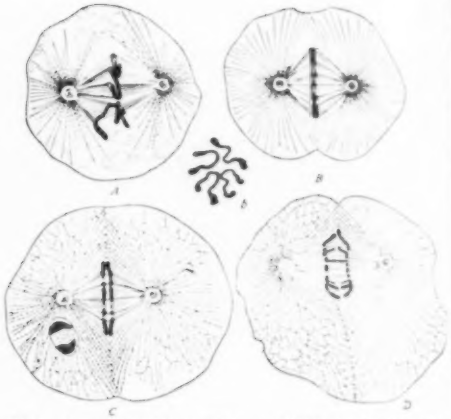
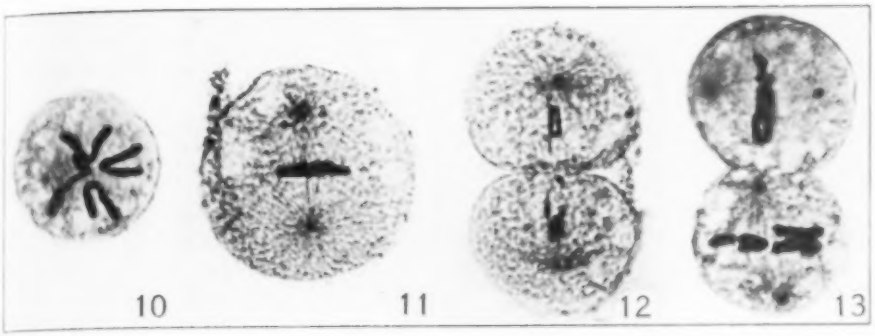


FIG. 9. MITOSIS IN A THREAD WORM, *Ascaris megalocepha'a* VAR. *bivalens*. DRAWINGS FROM FIXED AND SECTIONED EGGS, SHOWING THE AMPHIASTER. *A–D*. SIDE VIEWS. *b*. CHROMOSOME GROUP IN POLAR VIEW. (FROM WILSON AFTER BOVERI).

vation proved fruitful in two directions: In the first place it led to the experiment of fertilizing the half of a cut egg which had no nucleus, and thereby introducing a nucleus into something which was known to be incapable of development alone. When so fertilized, it was found that such fragments could develop, indicating that the sperm brought in the essential elements. And in the second place, it suggested a comparison of the respective influences of the male and the female parent on the characteristics of the offspring, on the principle that if the nucleus contained the important elements the male ought to have just as great an influence as the female in spite of the small size of the sperm. As will be indicated a little later, it was found that in general the male actually does have an influence equivalent to that of the female.[4]

Such considerations as these led eventually to the focussing of attention specifically on the nucleus, and to extensive

[4] Although extremely minute at first, the sperm head swells after entering the egg and eventually gives rise to a nucleus similar in size and constitution to that of the egg, as shown in Fig. 5. Fertilization is completed by the fusion of these nuclei.



FIGS. 10–13. PHOTOGRAPHS OF MITOSIS IN EGGS OF A THREAD WORM.

FIG. 10. FIRST CLEAVAGE DIVISION OF EGG; POLAR VIEW OF METAPHASE. (COMPARE WITH FIG. 9*b*.) FIG. 11. SAME STAGE IN SIDE VIEW SHOWING THE AMPHIASTER. FIG. 12. LATE ANAPHASE, CELL ALMOST COMPLETELY DIVIDED. FIG. 13. METAPHASE OF SECOND CLEAVAGE DIVISION SHOWING AMPHIASTERS IN SIDE VIEW, ORIENTED IN CHARACTERISTIC MANNER (FOR THIS EGG) AT RIGHT ANGLES TO ONE ANOTHER. NOT ALL CHROMOSOMES ARE IN VIEW IN FIGS. 11–13. ALL FIGURES FROM FIXED AND SECTIONED MATERIAL.

studies on its organization and behavior. Many observations had, of course, already been made in this field, and we can not attempt here to retain an exact chronological order in considering the subject. But the first feature of importance for our purpose which came out of the early studies was the demonstration that just as the nucleus is the most significant or prominent structure in the cell, so the most significant components of the nucleus are the bodies called chromosomes (the dark bodies shown in Fig. 6).

Indeed it soon became apparent that in many cases the nucleus is actually derived from the chromosomes, so that in general the chromosomes may be considered as representing the nucleus. In consequence, attention was diverted to a direct consideration of the chromosomes themselves.

This shift in attention led to a series of brilliant experiments by Boveri which in some respects marked the climax of the period under consideration. The material used for his experiments was the sea-urchin. Boveri found that he could fertilize the eggs of some species of sea-urchins with sperms from other species which developed in a different way, and then could trace the influence of each parent on the development of the hybrid embryo. And he found that

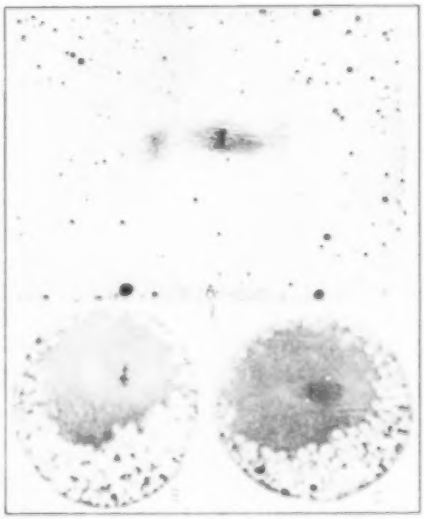
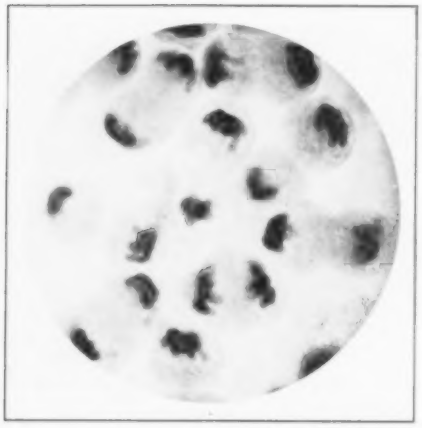


FIG. 14. PHOTOGRAPHS OF MITOSIS IN EGGS.

FROM FIXED AND SECTIONED PREPARATIONS SHOWING AMPHIASTER IN SIDE VIEW. *A*. SECOND CLEAVAGE OF WHITEFISH EGG (ENLARGED FROM FIG. 3 SHOWN ABOVE). *B*. MARINE WORM, *Nereis*, METAPHASE OF FIRST CLEAVAGE SHOWING LARGE ASTERS AND LONG ASTRAL RADIATIONS IN CYTOPLASM. *C*. SAME, ANAPHASE, SHOWING SEPARATION OF DAUGHTER CHROMOSOMES.



—*Courtesy of Mr. F. F. Lucas.*

FIG. 15. PHOTOGRAPH OF LIVING GRASSHOPPER CELLS TAKEN WITH ULTRA-VIOLET LIGHT.

LATE STAGES OF MITOSIS, SHOWING CHROMOSOMES PASSING TO THE POLES (OPPOSITE SIDES OF THE CELL) OR AFTER THEY HAVE ARRIVED AT THE POLES AND THE CELL HAS DIVIDED OR BEGUN TO DIVIDE.

development in these hybrids was not always the same; sometimes the embryo would develop in a fashion intermediate between that of the two parents, while in other cases it would develop just like normal embryos of the species from which the *mother* came. That is, in this latter case the sperm seemed to have no effect.

At first these results presented a puzzling mystery; but later the key to the solution was found in the fact that the peculiar differences in behavior were apparently due to corresponding differences in the behavior of the chromosomes in the various cases. In cases of the first type, for example, both the sperm chromosomes and egg chromosomes took part in development, hence the embryo was intermediate between the two parents, while in the second class of cases the sperm chromosomes degenerated and

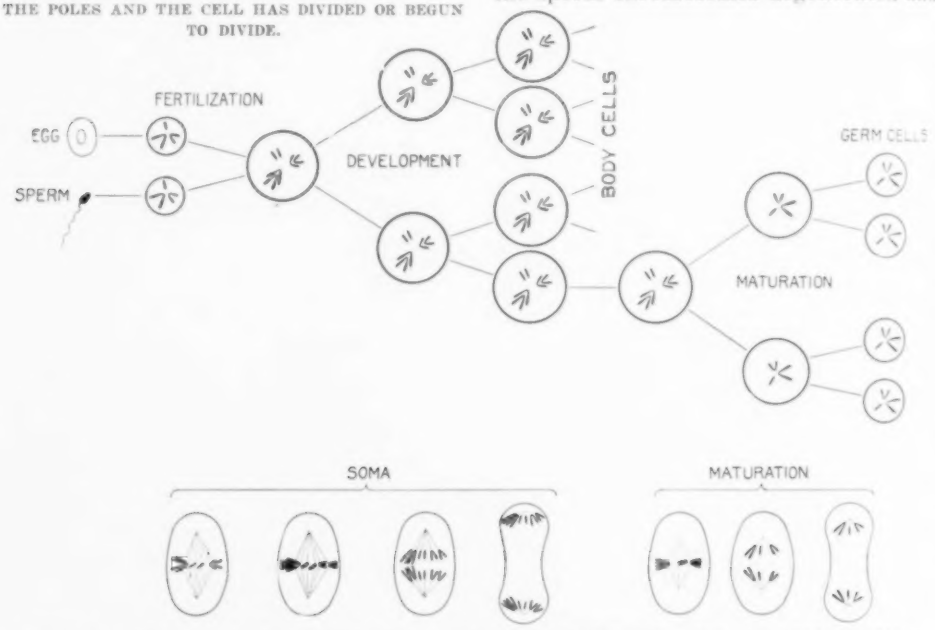


FIG. 16. DIAGRAM ILLUSTRATING THE HISTORY OF THE CHROMOSOMES DURING THE LIFE CYCLE OF AN ANIMAL.

ABOVE: EGG AND SPERM UNITE AT FERTILIZATION. EACH CONTAINS THREE CHROMOSOMES (IN THIS PARTICULAR SPECIES OF FRUIT FLY), AND HENCE CONTRIBUTES EQUALLY TO THE CHROMOSOMES OF THE OFFSPRING. THE CHROMOSOME GROUP IS PERPETUATED DURING DEVELOPMENT BY MEANS OF ORDINARY MITOSIS. WHEN THE GERM CELLS ARE FORMED, HOWEVER, THE NUMBER OF CHROMOSOMES IS ACCURATELY REDUCED BY A SPECIAL MITOSIS DURING "MATURATION" WHICH BRINGS ABOUT A SEPARATION OF CORRESPONDING CHROMOSOMES. BELOW: THE TWO TYPES OF MITOSIS SEEN IN SIDE VIEW.

FIGS. 17–19. PHOTOGRAPHS OF CHROMOSOME GROUPS IN FLIES, SHOWING DIFFERENCES IN NUMBER, SIZE AND FORM OF CHROMOSOMES.

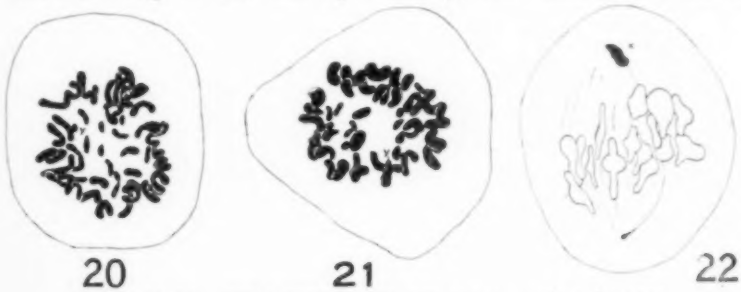
FIG. 17. THE FIVE ROD-LIKE PAIRS IN A BODY CELL OF THE FRUIT FLY *Drosophila virilis*. FIG. 18. SIMILAR VIEW OF CHROMOSOME GROUP IN ANOTHER FRUIT FLY, *Drosophila funebris*, SHOWING FOUR SHORT ROD-LIKE PAIRS, ONE LONG ROD-LIKE PAIR (BELOW) AND ONE EXTREMELY SMALL DOT-LIKE PAIR (IN CENTER, THE MEMBERS NOT VERY CLOSE TOGETHER). FIG. 19. TWO GERM CELL GROUPS IN A BLOW FLY, AFTER THE CHROMOSOME NUMBER HAS BEEN REDUCED AT MATURATION. SIX CHROMOSOMES IN EACH GROUP, INCLUDING TWO ROD-LIKE, ONE DOT-LIKE AND THREE V-SHAPED MEMBERS. AT FERTILIZATION TWO SUCH GROUPS ARE BROUGHT TOGETHER, GIVING A GROUP SIMILAR TO THAT SHOWN IN FIG. 7, EXCEPT FOR SIZE RELATIONS.

did not take part in development, hence the embryo developed like its mother.

Thus, as far as could be observed, development seemed to be dependent on the chromosomes, without any clear relation to other constituents. In addition to this, it was being shown by other investigators at the same time that attempts to correlate development with other visible materials in the egg led to a variety of conflicting results which could only be harmonized on the assumption that these other materials played a secondary rôle.

So the upshot of the work of this whole period as regards the present subject was that nothing in the cell appeared consistently to bear any such relation to development as did the chromosomes. Much was thus accomplished by centering attention on the chromosomes, but it seemed impossible to go beyond this and get direct evidence as to *how* or *why* the chromosomes performed their unique function. The investigators, as one of them expressed it, were "confronted by a stone wall."

Looking back on that period now it is not difficult to see that the obstacle to further progress consisted in large measure of two things: First an insufficient knowledge of the chromosomes themselves—their structure, behavior, constancy, etc.—and second an insufficient



FIGS. 20–22. CHROMOSOMES OF MAN. *After Painter.*

FIGS. 20 AND 21. POLAR VIEW SHOWING ENTIRE CHROMOSOME GROUP, AS FOUND IN BODY CELLS AND SPERMATOGONIA (GERM CELLS OF MALE BEFORE MATURATION). FIG. 22. MATURATION DIVISION IN MALE SHOWING SEPARATION OF THE TWO SEX CHROMOSOMES (LARGE X AND SMALL Y).

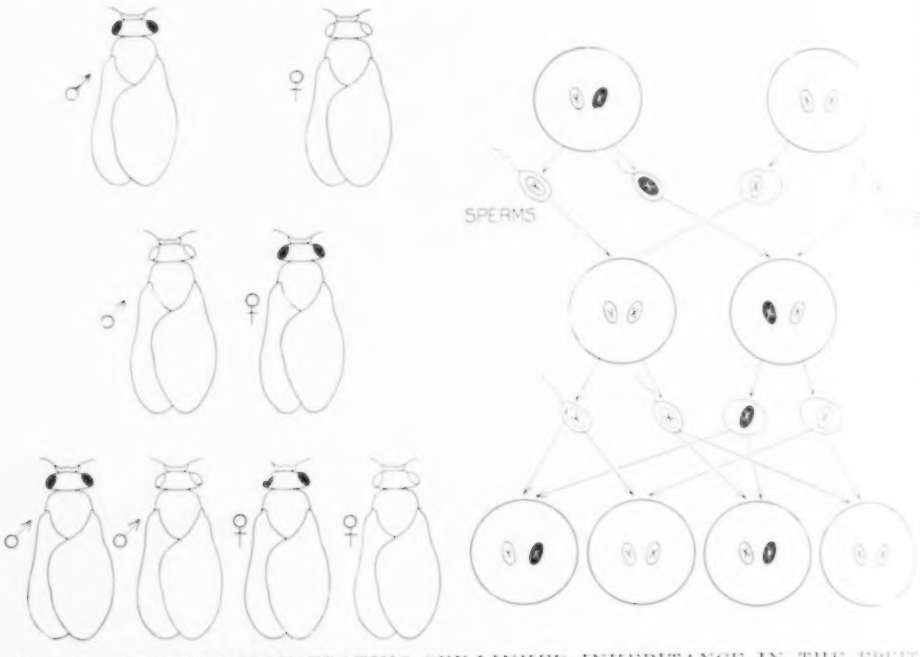


FIG. 23. DIAGRAM ILLUSTRATING SEX-LINKED INHERITANCE IN THE FRUIT FLY *Drosophila*. *From Sharp, after Morgan.*

♂, MALE; ♀, FEMALE; X-CHROMOSOME INDICATED BY *X*; Y-CHROMOSOME BY *Y*; RED EYES REPRESENTED IN BLACK; WHITE EYES IN OUTLINE. THE X-CHROMOSOME CARRYING THE GENE FOR RED EYE COLOR IS REPRESENTED IN BLACK. SINCE THIS GENE IS "DOMINANT" ANY FLY RECEIVING IT HAS RED EYES. SINCE THE X-CHROMOSOME OF THE MALE ALWAYS PASSES TO DAUGHTERS, AND THE *Y* (WHICH DOES NOT CARRY THE GENES UNDER CONSIDERATION) PASSES TO SONS, "CRISS CROSS" INHERITANCE RESULTS IN THE FIRST GENERATION—THE DAUGHTERS BEING LIKE THE FATHER AND THE SONS LIKE THE MOTHER.

knowledge of heredity, or what is now known as the field of genetics, particularly that part of genetics which shows the relation between the chromosomes and heredity. For studies on these subjects a different method was required.

Hence it is no mere coincidence that the intensive study of chromosomes under the microscope, and the study of heredity (*i.e.*, genetics) entered their most productive period just as these activities in experimental embryology subsided. In both of the new fields just mentioned there has been great activity for the past twenty years or more—an activity resulting in a detailed knowledge of chromosomes and of heredity which is not only significant on its own account, but which has thrown a new light on development, and has also, it seems to me, made it possible now to attack the problems of development in a new fashion and with a new tool.

It is for this reason, therefore, that in considering development from the standpoint of the geneticist I would invite attention particularly to the correlated results of studies on chromosomes and on heredity. The limitations of space necessitate making such a review very brief, hence it will be necessary to omit many features entirely and pass over others with only a few words. What I hope to do specifically is to give a brief picture of what the chromosomes are and how they behave, and then to indicate

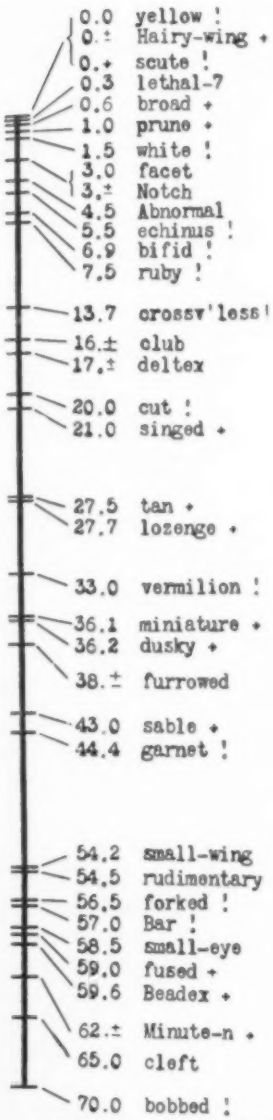


FIG. 24. "MAP" OF THE X-CHROMOSOME IN THE FRUIT FLY *Drosophila melanogaster*. *After Morgan, Bridges and Sturtevant.*

CROSS LINES REPRESENT THE RELATIVE "POSITIONS" OF THE GENES RESPONSIBLE FOR THE CHARACTERS INDICATED AT THE RIGHT.

the rôle they play in heredity and the relation which they must, on that account, bear to development.

In doing this let me recall the fact brought out by Dr. Streeter in the first article of this series, that the development of the egg is not completed until the animal has become fully grown and mature. Consequently, we are as much concerned with processes occurring in the embryo or individual after it has passed the so-called "egg stage" as with those transpiring during this stage.

When viewed under the microscope in prepared specimens the chromosomes appear about as shown in the accompanying photograph of a cell of one of the robber flies (Fig. 6). In this particular case the chromosomes are of different shapes and sizes. Each body cell in the whole animal has this same set of chromosomes. To give some idea of the minute size of these structures it may be observed that the entire field shown in the photograph is far below the limit of vision with the naked eye. Another illustration is seen in Fig. 7, from a similar photograph of the chromosomes of the common house fly, which has a somewhat different group of chromosomes.

In both of these photographs the chromosomes have been shown at the time the cell is about ready to divide, which is the stage at which the chromosomes are most compact and the only stage at which they are arranged in one plane in such a way that they may all be photographed at once. At other times they move about in the nucleus and change their shape and consistency. Also when the cell is about to divide the nuclear membrane breaks down leaving the chromosomes lying free in the cell. For present purposes, however, we may disregard these changes in form, etc. (which apparently have to do with the physiological activity of the chromosomes) and think of the chromosomes as shown in the figures.

If we trace the history of any cell during development—either the egg cell, or one of the cells descended from it—we find that when the cell divides to

FIGS. 25 AND 26. DETAILS OF CHROMOSOME STRUCTURE.

25 *a* AND *b*, LOW AND HIGH MAGNIFICATION, RESPECTIVELY, OF CHROMOSOME PAIRS IN A LILY (AFTER BELLING). FIG. 26. GRASSHOPPER CHROMOSOMES (AFTER WENRICH). THREE DRAWINGS REPRESENTING ONE PARTICULAR PAIR OF CHROMOSOMES AS SEEN IN THREE DIFFERENT CELLS, SHOWING THE CONSTANCY OF THE STRUCTURAL ORGANIZATION OF THE CHROMOSOME. THESE FIGURES REPRESENT THE STAGE AT MATURATION DURING WHICH THE TWO HOMOLOGOUS CHROMOSOMES ARE INTIMATELY ASSOCIATED. NOTE THE CORRESPONDENCE IN STRUCTURE OF HOMOLOGUES IN BOTH FIG. 25 AND FIG. 26.

make two daughter cells the chromosomes also divide, so that each daughter cell receives half of each chromosome, thus keeping the chromosome group constant in all the cells (save for certain special cases to be considered later). This process is shown diagrammatically in Fig. 8. At first the chromosomes become arranged in one plane in the center of the cell, then each one divides lengthwise in a precise fashion, and the two daughter halves go to opposite sides of the cell. After this is accomplished the cell divides and each daughter cell has the full set of chromosomes, each chromosome being a replica of its ancestor.

The actual processes taking place here are very delicate and accurate, and in the cells as seen under the microscope at this stage there is a beautiful, bipolar structure called the "amphiaster" which apparently represents the mechanism responsible for the distribution of the chromosomes. This structure is shown better in the accompanying drawings of the dividing egg of one of the parasitic thread worms (Fig. 9). Here the astral structures are especially clear, with rays running out into the cell, and also with rays extending to the chromosomes, making the so-called "spindle fibers" which look as if they were actually pulling the halves of the chromosomes to the two poles of the figure (as shown in B, C and D). The latter drawings represent side views. When viewed from one pole the chromosomes appear as shown in (b)—this species having four long, V-shaped chromosomes. Photographs of such stages taken directly from the eggs after they have been fixed and stained for study are shown in Figs. 10 to 12. The first represents the chromosome group as seen from one pole; the second represents the same stage in side view, showing the chromosomes at the equator of the figure as the cell is preparing to divide, and the third shows the chromosomes after they have divided and are part way toward the poles of the figure (not all chromosomes in view here). And finally, in Fig. 13 is shown a later stage, after division has been completed and the two daughter cells are getting ready to divide again.

Another series of mitotic figures is shown in Fig. 14. These photographs are from material especially favorable for study of the astral and spindle structures rather than the chromosomes. The first is a more highly magnified view of

the amphiaster shown in Fig. 3, from the whitefish. The other two represent stages in the first cleavage of eggs of the marine worm, *Nereis*, preceding the two-cell stage shown in Fig. 2.

The preceding photographs all represent conditions as seen in prepared material, and it may be of interest to note that, so far as the chromosomes are concerned, the essential features are also visible in the living cells. It is even possible to show them in photographs of living cells with the aid of ultra-violet light, as indicated by the accompanying photograph of cell division in one of the grasshoppers, taken by Mr. Lucas (Fig. 15). In this material the chromosomes are too numerous and crowded to be shown individually at such stages, but the essential characteristics are entirely clear. The stages represented in the photograph are relatively late, after the chromosomes have arrived at the poles and the cells are dividing or about to divide.

We see, then, that the cell has a highly specialized, delicate mechanism which insures the accurate division and distribution of the chromosomes at each cell division, so that as the organism develops each cell gets the exact set of chromosomes with which the fertilized egg began its development. In other words, organisms have, somehow, during the course of evolution, developed a method which insures the perpetuation of the chromosome group from cell to cell.

It is a remarkable fact that this process is essentially universal in all animals and plants. We must assume, therefore, since it involves such a complicated and delicate procedure, that it has a special general significance, and that the bodies which are so accurately divided and distributed must be of special importance.

This fact has long been appreciated. Indeed it was recognized during the period of embryological activity just considered, and it was one of the experimental embryologists, Roux, who first pointed out the possible significance of the processes. According to Roux this accurate longitudinal division of the chromosomes and the precise distribution of the daughter halves could only be understood on the assumption that each chromosome is a composite of different materials, presumably different chemicals, which are arranged in series along the length of the chromosome and are divided so that each one is handed on to the daughter cells at each division. Also, on his view, such a process would be meaningless unless these different materials were highly important for the life of the cell and were all required for the proper development of the organism.

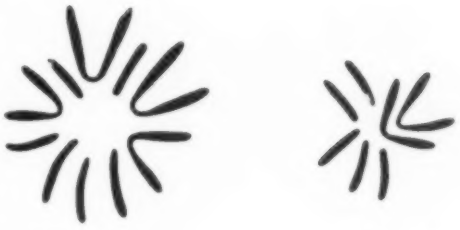
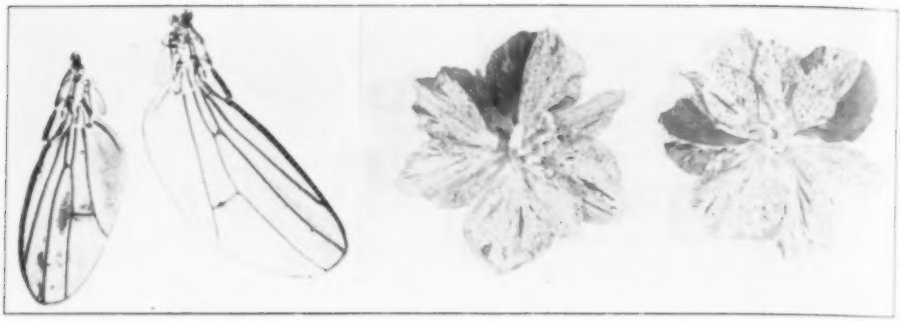


FIG. 27. CHROMOSOME GROUPS OF GERM-LINE AND SOMA IN MALES OF THE FUNGUS FLY *Sciara coprophila*.

SCHEMATIZED DRAWINGS. THE SOMATIC (BODY) CELLS LACK THREE OF THE CHROMOSOMES PRESENT IN THE CELLS OF THE GERM-LINE

This far-reaching deduction did much to stimulate further work on the subject. In fact, it may be said to have laid the theoretical foundation for modern genetics. For a long time it was vigorously opposed, and there are some even now who are inclined to regard it with marked skepticism, but the accumulated evidence of the last twenty years has served to verify it so completely that few unprejudiced students of the subject at the present time question its essential correctness.

One of its first strong supports came from another line of evidence derived



—*Courtesy Dr. M. Demerec.*

FIGS. 28 AND 29. EFFECTS OF FREQUENTLY MUTATING GENES.

FIG. 28. THE TWO WINGS OF A SINGLE FRUIT FLY, *Drosophila virilis*, IN WHICH PART OF ONE WING IS GREATLY ENLARGED DUE TO MUTATION OF A CERTAIN GENE DURING DEVELOPMENT. FIG. 29. TWO FLOWERS OF THE LARKSPUR, *Delphinium*, SHOWING DARK (BLUE) SPOTS OF DIFFERENT SIZES ON THE PINK PETALS DUE TO MUTATION OF A GENE INFLUENCING PETAL COLOR.

from the early work. This dealt with the history of the chromosomes when traced through the entire life cycle of an animal. We have already noted how the chromosomes are transmitted from cell to cell as the egg develops. But we have not yet dealt with their transmission from one generation of animals to another. This is indicated in the accompanying diagram (Fig. 16) which represents schematically the history of the chromosomes in the life of one individual. In constructing this diagram I have not taken a hypothetical case, but have used one with which I am personally familiar—a species of fruit fly belonging to the genus *Drosophila*. This fly is particularly favorable because the egg and the sperm each contain only three chromosomes, and each of these chromosomes differs from the other two, so its history may be followed individually. It will be observed that for each chromosome contributed by the egg there is a corresponding one contributed by the sperm. Consequently, in the fertilized egg the chromosomes are present in homologous pairs. In these particular animals, as a matter of fact, the chromosomes actually associate in pairs as shown in the figures.

After fertilization, during the development of the embryo from the egg, the chromosomes divide at each cell division, in the manner already indicated, so that all the cells receive the full set of chromosomes. Such a process continues consistently up to the time the final germ cells are to be formed; then in the particular cells which are going to give rise to eggs or sperms a different procedure is followed.

It is evident that if the egg and the sperm each received the full number of chromosomes, fertilization would bring together two full sets and the number would be doubled at each generation. That does not occur, however, because in these particular cells, instead of each chromosome dividing and sending daughter halves to the daughter cells, the two members of each pair of homologues come together and then separate into opposite cells, so the resulting germ cells have only half the original number.

The actual processes taking place here (collectively known as "maturation") are very elaborate and are of deeper significance than I have indicated, but the essential feature is this accurate segregation of the chromosomes so that each germ cell gets just one of each kind. Then at fertilization these single sets of chromosomes are brought together again.

giving the organism the double set. Thus we find a regulatory process coming in at each generation which keeps the chromosome number from doubling. And here again we find that this specialized proceeding is not limited to a few forms but is characteristic of animals and plants generally, thus indicating in further measure the significance of the individual chromosomes.

It follows from these considerations that the number of chromosomes and the configuration of the chromosome group should be constant for each species, and this is indeed found to be the case. The chromosome groups of different species may be, and often are, very different from one another, but within a species there is constancy. Space will not permit an illustration of the various types of chromosome groups and the range of numbers found in animals, extending from two chromosomes in one of the thread worms up to more than two hundred in certain other animals (*e.g.*, some of the Crustacea), but a few illustrations may be given to indicate some of the differences which may be found within one group of animals. For this purpose I have chosen the flies, partly because this is a group with which I am personally familiar, and partly because this group is particularly favorable for the purpose on account of the association of the chromosomes in pairs. Fig. 17 is from a photograph of the chromosomes in one of the fruit flies (*Drosophila virilis*) showing the five pairs of rod-like chromosomes. Fig. 18 represents the chromosomes of another species of fruit fly (*Drosophila funebris*). The group here involves four pairs of small rod-like chromosomes and one pair of much longer rod-like ones, together with a pair of very small dot-like members in the center, so small as to be almost invisible. In the photograph shown in Fig. 19 the chromosomes in two germ cells from one of the blowflies are represented. It will be observed that these cells have just one chromosome of each kind, and that for each member in one cell there is a corresponding one in the other. At fertilization two such groups are brought together.

Finally, in the photograph from one of the robber flies, as noted above (Fig. 6) we have a still different group, with chromosomes of various shapes and sizes. Since this group is in one of the embryonic cells, before the final germ cells are formed, it has two chromosomes of each kind—*except for one particular chromosome*, the small, spherical one. This brings out the next feature of special significance for our purpose. The fly possessing this group is a male, and it has only one of these small chromosomes. The female fly of this same species, on the other hand, has two such chromosomes. They are the so-called "sex chromosomes" or "X-chromosomes." Conditions represented in this fly are typical of those in a great many animals; indeed, with a slight modification they may be said to apply to most animals, including man.

Such a relation between chromosomes and sex has long been known and has led to extensive studies on the sex chromosomes of many animals. As a result of these studies, particularly those combined with breeding experiments, it is clear that this pair of chromosomes (or this chromosome) is primarily responsible for determining the sex of the animal.

The mechanism by which this is effected is that which we have already considered in connection with germ cell formation, *i.e.*, the process of reduction in chromosome number. Since in the male there is only one chromosome of this kind present when, among the other chromosomes, the two members of a pair are separated into different cells, it has to go into one cell, leaving the other cell without any sex chromosome. As a result half the sperms receive this chromosome and the other half do not,

and the eggs fertilized by the former become females, while those fertilized by the latter become males. In some forms conditions are somewhat modified by the presence in the male of a second sex chromosome called the Y-chromosome, which differs from the X in constitution and often in size. Two types of sperms are formed here, just as in the other cases, but those entering into the production of males receive the Y-chromosome instead of no sex chromosome at all. This process may be illustrated in the case of man, as shown in Figs. 20 to 22. In the first two drawings the full chromosome group of man is shown, and in the last is represented the spermatocyte division at which the X-chromosome passes to one pole, and hence to one germ cell, while the Y passes to the other. These features will be amplified later; what is desired at this point is to emphasize the fact that these particular chromosomes "determine" the sex of the animal.

Such an effect can only be produced, of course, by an influence on development, and in many cases on the development of almost all parts of the organism, for the difference between the male and female often extends to practically all the major structures of the body. It is evident, therefore, that here the processes of development leading to extensive structural differences are influenced, and in this sense controlled, by one particular chromosome, or pair of chromosomes.

Not only has this general relation been established between a specific chromosome and specific types of development, but these same studies, and others involving breeding experiments, have gone a considerable way toward showing how the relation is effected. It has been shown, for instance, in numerous animals, that the influence of the sex chromosome is not limited to sex characters, but extends to other characters as well. It has also been shown that these influences are not exerted by the chromosome as a whole in the form of a mass effect, but that within the chromosome there are discrete elements of some kind, each of which has its own specific effect. Furthermore, it has been shown that these discrete elements have a definite and constant relation to one another in the chromosome—presumably a serial order along the length of the chromosome—and that when the chromosome divides each of these divides. In other words, the evidence has provided a complete verification of Roux's hypothesis that the chromosome is composed of a series of qualitatively different, self-propagating elements.

These results have come from the combined studies of many investigators on various organisms, but particularly from the studies of Morgan, Sturtevant, Bridges and Muller on the fruit fly *Drosophila*. We can not go into the details here of how this evidence has been obtained, but a few experiments may be cited as examples of the method employed. These experiments have made use of the so-called sports or "mutations" which occasionally appear in any species of animal or plant. Familiar examples of such sports are seen, for instance, in albino animals, such as white mice or white crows or white ducks, also in many of the fancy types of pigeons, such as fantails, and many cultivated varieties of flowers, such as double roses, red sunflowers, etc.

These sports or mutations arose by sudden and apparently spontaneous changes from the parent strains (hence the name mutation). Since the characters are inherited they must be due to changes in the germ-plasm; but as already indicated, it has been found that instead of these being general changes in the germ-plasm as a whole, they are localized modifications in the individual chromosomes.

For example, in one of the fruit flies a white eyed strain arose from the ordinary red eyed type. The inheritance of

this white eye character is illustrated in the accompanying diagrams (Fig. 23). When a red eyed male is mated to a white eyed female the daughters are all red eyed like the father and the sons all white eyed like the mother. The reason for this is seen in the history of the sex chromosomes, shown on the right. The X-chromosome of the red eyed father is represented in black, and that of the white eyed mother in white. We know that in the male, when the sperms are formed, only half of them receive this X-chromosome, and that the eggs they fertilize become females. The other half of the sperms will lack this chromosome (possessing the differently constituted Y-chromosome instead), and the eggs they fertilize will become males. The male, then, gets his X-chromosome from his mother and hence is white eyed, while the female gets one X from each parent; and since the red is dominant over the white she has red eyes.

In the next generation the same principle applies, although the actual results are different because the mother here produces eggs of two kinds, one with the white-carrying chromosome and the other with the chromosome carrying red. As a result both types are present among the sons and daughters alike.

Scores of other examples of this type of inheritance could be cited from many animals, including man himself, where such characters as haemophilia and night blindness are "determined" by the sex chromosome.

In the fruit fly just mentioned (*Drosophila melanogaster*), which has been studied so extensively by Professor Morgan and his associates, more than thirty characters are known to be due to separate changes in the X-chromosome. Since each of these behaves as a unit it has been possible to study their interrelations. Such studies have shown that the materials in the chromosome which are responsible for the characters also behave as units and that in the female, where two such chromosomes are present, interchanges of these units take place between the two chromosomes. It is through the study of these interchanges that the units have been shown to bear a serial relation to one another, each occupying a definite, permanent position in the series.

If this is true of the sex chromosome we should expect to find it also true of the other chromosomes; and such is actually the case, as shown by extensive studies on both animals and plants. Studies along these lines have even gone so far as to make it possible to construct diagrams or "maps" of the different chromosomes in some species, showing the relative "location" of these hereditary units, or "genes" as they are technically called. Such a map is shown, for example, in Fig. 24. It represents the X-chromosome of the fruit fly *Drosophila melanogaster*. The heavy line designates the chromosome itself and the cross markings on it indicate the "locations" of the units or genes. Just how accurately these maps represent the locations of the materials in the chromosomes is uncertain, but there is good evidence from certain special experiments, which we can not go into here, that in a general way they actually indicate the spatial relations.

As already intimated, the studies in this field have verified the conception that among the ordinary chromosomes the two members of a pair—one from the father and one from the mother—are alike in composition, whereas the members of different pairs are unlike in make-up.

The genetic evidence on this point seems entirely convincing by itself; but it may be of interest to note that the same conclusion is reached by direct observation of the structure of the chromosomes under the microscope. In many cases it is possible to see an internal structure in the chromosomes, as shown in the accompanying figure (Fig.

25) from the work of my colleague Dr. Belling, who has identified what may represent the actual genes in the chromosomes (the delicate granules). It is also possible to identify individual chromosomes by means of their internal structure. This is indicated in the accompanying figures from Wenrich's work on the grasshopper, in which the small bodies in the chromosomes are of different sizes and shapes and make up a definite architecture for each chromosome (Fig. 26).

We arrive, then, at a conception of the chromosomes as composite structures made up of multitudes of different minute elements, the genes, arranged in an orderly fashion and each playing its own particular rôle and having its own particular influence on the organism. In most cases thus far studied this influence is known only from its end result in the adult organism, but that is mainly because it is only the end result which has been studied. If the intermediate stages were followed with accuracy it would be found that the end result is due to modifications in the processes of development. Much work is being done along this line at the present time, and numerous cases are now known in which the effects of these individual elements, or genes, may be traced in the development of the organism.

Some genes, for instance, are known to affect the rate of growth, either of the entire organism or of certain parts; others are known to influence the process of differentiation—thus showing the influence of genes on both of the fundamental aspects of development. From this it is only a step, of course, to the conclusion that development as a whole is largely brought about or controlled in some way through the influence of the genes, and it is now widely accepted that in a broad sense this is true.

When we come to the question of *how* this influence is exerted, however, we come to the frontier of present knowledge on the subject and our answer can not be specific. The question will be asked at once, for example, as to how differentiation of the tissues and organs of the body can be due to the genes if the cells in these different tissues all have the same sets of chromosomes and hence of genes. This is one of the problems upon which attention is being centered at the present time. The difficulty was recognized long ago by Weismann, who developed on that account his theory of individual units or ids—a theory which anticipated many of the features established by modern genetics. In his scheme Weismann assumed that these (to him purely theoretical) units were assorted among the different tissues of the embryo as the cells divided during development, so that each cell received its own particular assortment of ids and hence went into the make-up of a particular kind of tissue or organ, with only the ancestors of the germ cells retaining the full complement of ids. It is now known that this view can not be accepted in a literal sense, but it is not yet clear as to how far it misses the mark.

In studies on this problem attention may be focussed either on the behavior of individual genes or on that of groups of genes, as represented, for instance, by entire chromosomes—and both methods are, in fact, being used. I will only cite two illustrations with which I happen to be familiar, taking first a case involving whole chromosomes. As already implied, the evidence indicates that *for the most part* there is no sorting out of individual chromosomes in development so that certain tissues receive some that others lack; but in a few cases there are indications that a process somewhat of this kind actually does occur to a limited extent.

We are working on such a case at the present time, for example, in one of the flies. In this particular species, or group of species, the evidence indicates that in the development of the male fly, as the

egg divides to form the first visibly different cells of the embryo, the cells which represent the ancestors of the germ cells receive the complete set of chromosomes, but those which are to give rise to the body tissues lose three of the ten chromosomes, and hence develop with a distinctly different number, as indicated in Fig. 27. In the body tissues the two very large chromosomes and one of the smaller rod-like chromosomes are lacking. In the development of the female fly a somewhat different process occurs, which we have not yet analyzed further than to show that the body cells have eight instead of seven chromosomes.

It is of interest to note also, in connection with this case, that we have been able to show that the type of chromosome elimination which occurs here is predetermined, before the egg begins its development, by the genes in one particular chromosome of the mother producing the egg. Although it seems certain that this process of chromosome elimination is not of general occurrence in other animals, its presence here indicates that particular influences may be brought to bear on particular chromosomes at definite stages in early development, and that these are due to specific genes.

When consideration is given to the other mode of study, *i.e.*, following the behavior of *individual genes* during development, particular interest attaches to those cases in which certain genes have the property of changing during the course of development. What the nature of this change is, or how it occurs, is not known, but it leads to definite influences on development and promises to be very useful for further study. It is responsible, for instance, for certain types of variegation in plants and of mosaic pattern or spotting in animals. An illustration of this is seen in the case of one of the fruit flies being studied by my colleague, Dr. Demerec, as shown in Fig. 28. Here a certain gene, which affects the size of the wings, changes (mutates) frequently during the course of development, producing enlarged regions in the wings. In this particular specimen nearly all of one wing is enlarged.

Similarly in the variegated flowers of the larkspur, Delphinium, which he is studying, the dark patches of blue on the pink petals (Fig. 29) are due to such spontaneous changes of a certain gene which influences the production of color. How much this phenomenon of changing of individual genes in different parts of the body during development may have to do with explaining differentiation in general is not known. It may be one of the factors involved, but at present it seems probable that ordinarily most of the genes do not change their make-up during development, and that their differentiating influences are exerted in some other manner.

The subject of gene function, however, is still in its infancy, and at present only theoretical interpretations can be offered. In a general way, it may be said with some confidence that the genes represent chemical materials and that these chemical units influence the physiological processes in the cells and cause the cells to interact upon one another in a certain manner and in a certain sequence.

It is generally agreed, I believe, that development represents a chain of processes, each one of which influences, and to some extent determines, the nature of subsequent ones. Consequently we may, perhaps, picture the story in a hypothetical way somewhat in this fashion: Starting with an egg of a given composition and structure, which has been determined primarily by the genes of the mother, development is induced by the entrance of the sperm, which brings in a set of genes from the father, and then proceeds under the influence of these two corresponding sets of genes, each gene performing its own function

in influencing conditions and processes in the cell and probably being influenced in turn by conditions already existing in the cell.

One view also postulates that at the beginning, owing to the particular materials and conditions in the cell, certain genes are stimulated to greater activity than others, and that as development proceeds other genes become more active at certain times and in certain cells, due in part to the position of these cells in the embryo and to the different distribution of other than chromosomal material, as the original materials of the egg (cytoplasm) are apportioned to the various cells descending from it. On this hypothesis we may picture a reciprocal action going on between the genes and their surroundings, the genes at one stage determining to some extent what the surroundings are going to be at a later stage and these in turn causing certain activities of the genes or chromosomes which will predetermine to a certain extent what is going to occur at a still later stage.

This is only one of the various possible views, and is, of course, an extremely crude picture; but to attempt a detailed and specific interpretation of the functional processes at this time would not only take us deeply into physiology and biochemistry, but would lead us farther and farther from the foundation of actual experimental results. This aspect of the question, therefore, must be left for the future, and we must be content at present to have obtained a fair idea of why the chromosomes, or genes, may be looked upon as playing a primary rôle in the processes under consideration even if we know little about how they do it.

THE WATER SUPPLY OF CITIES IN THE UNITED STATES

By Professor ROBERT M. BROWN
RHODE ISLAND COLLEGE OF EDUCATION

THE problem of distribution of water to urban communities in the United States varies with conditions and may be considered under categories of quantity and quality. Quantity is a problem in arid and semi-arid communities of growing population and humid areas of dense settlements, while in the moderately densely and sparsely settled areas under humid conditions an ample supply of water can be obtained. Quality, the desideratum being a water that is clear, tasteless, free from pollution and soft, does not lend itself so easily to regional distribution; turbidity occurs where the source of supply is a river and is slight in impounded waters; taste is a seasonal and at times a local phenomenon; pollution arises from the character and density of populations; and hardness results from the soluble character of soil and rocks.

SOURCES OF SUPPLY AND CONSUMPTION

There are 68 cities in the United States with a population in 1920 of over 100,000. Of these five obtain their supply of water from the Great Lakes; Chicago and Milwaukee from Lake Michigan, Detroit from the St. Clair River; Buffalo and Cleveland from Lake Erie. Twelve receive their supply from great rivers: Minneapolis and New Orleans from the Mississippi River; Cincinnati and Louisville from the Ohio River; Nashville from the Cumberland River; Washington from the Potomac River; Kansas City, Missouri, Omaha and Kansas City, Kansas, from the Missouri River; and Albany from the Hudson River. Seven cities of this class—Memphis, Spokane, Lowell, Houston, Camden, San Antonio and Dayton—obtain water by sinking wells. Rochester, New York City, Indianapolis and St. Paul use wells in part. The remaining forty-two depend on surface drainage or small streams and ponds with a fluctuating flow and in most cases limited in amount. Denver, for example, finds that the water supply from the South Platte River is not sufficient for her future needs, and plans the diversion of water from the west slope of the Rocky Mountains. The new Moffat Tunnel can be used only on the Fraser River to divert 106,000 acre feet, which is less than her demands will be in the near future as based on her population curve. The entire plan involves a total diversion of 250,000 acre feet through the mountains. On the other hand, San Francisco, on the completion of the new Hetch Hetchy system, together with the Spring Valley Water Company, recently acquired by the city, will have 62,000 acres in the water shed with a capacity of 65,000,000,000 gallons, and this will yield even during a succession of seven or eight seasons of scanty rainfall a daily quantity in excess of her needs. In the densely settled sections of the United States and particularly in the area from Pennsylvania to Massachusetts, where surface drainage is largely the source of the water supply, it is estimated that with proper storage facilities the yield will average about 500,000 gallons per day per square mile.

The average consumption of water per day per capita for 200 cities in the United States is about 140 gallons. There appears to be no strong correlation between per capita consumption

and population, although in general the smaller cities have a less per capita consumption than the larger. Cities having a population of 500,000 or over in 1915 had a per capita consumption of 150; those between 300,000 and 500,000, 149; those between 100,000 and 300,000, 123; and those between 30,000 and 50,000, 123.[1] Consumption is a variable dependent also on the type of industry.

Cities with excessive per capita consumption include: Tacoma, 430; Buffalo, 324; Pittsburgh, 253; Albany, 230; Chicago, 226, and Salt Lake City, 203. And with a low per capita consumption: Fall River, 48; Hartford, 64; Providence, 65; St. Paul, 70; Worcester, 78; and Memphis, 87.

The excessive use of water is due to waste, and metering is the only remedy. This conclusion is supported as follows:

Seventeen New York State cities which pumped at least a part of their water by steam or electric power had 75 per cent. or less of their systems metered. The average per capita consumption of these was 234 gallons per 24 hours. Six of these reported a per capita consumption above this average. Fifteen cities in New York State, which pumped at least a part of their water, either by steam or electric power, had more than 75 per cent. of their systems metered. The average per capita consumption of these was 99 gallons per 24 hours. Seven of these cities reported a daily per capita consumption in excess of this average. Of the 201 American cities having at least 75 per cent. of their system metered, the daily average per capita consumption is 96 gallons.

The daily average per capita consumption of New York State cities whose systems were 100 per cent. metered was 98 gallons, and the average of American cities all of whose services are metered is reported to be 85 gallons.[2]

Tacoma, which stands at the head of the list of excessive per capita usage, admits that there is a large wastage by overflow and but 8 per cent. of the water is metered. Buffalo has but 32 per cent. of water metered; Pittsburgh 15 per cent.; Albany 33 per cent.; Chicago 22 per cent. and Salt Lake City 33 per cent., while the cities of low per capita consumption are metered thus: Fall River 57 per cent.; Hartford 100 per cent.; Providence 70 per cent.; St. Paul 61 per cent.; Worcester 74 per cent.; and Memphis 60 per cent.[3]

Cities have accomplished much in providing water but little in the economical use of it.

Adequacy of Supply and Conflicts in Uses

The larger problems of water supply in arid and semi-arid lands are in general known. In humid areas where many people reside the problem of water supply becomes acute in those regions where the source of supply is drawn from secondary streams. Great Lakes cities have an abundance; cities drawing water from large rivers are practically immune from shortage. Even during the excessive droughts of the summer of 1930 no city tapping the Mississippi River or its large tributaries reported any danger of failure of their water supply, although the Mississippi River was making a new record in low water stages.

Eastern cities were not so fortunate, and during the past summer (1930) drought conditions caused water supply boards to prohibit in instances the use of water for lawns and the washing of automobiles. Schools have been closed, Monday wash day banned, tub baths limited to one a week and even a drinking water shortage threatened: while country places have been in many cases in distress. In many cities the supply is adequate if rains are fairly regular, but a serious deficiency of water is the

[1] General Statistics of Cities, 1915. Washington, 1916.

[2] "Water Consumption in New York State Cities and its Effect on Coal Consumption." Special Report, Albany, N. Y. August 11, 1922.

[3] The percentages are taken from "General Statistics of Cities, 1915." Department of Commerce, Washington, 1916.

experience of too many communities when a long dry spell is experienced.

To-day, in the eastern populated district, towns and cities are competing for drainage areas, and protection for present supply and particularly for future needs is a new problem that must be considered. No adequate estimate of future requirements has been made and no great regulations covering the rights of other communities have been formulated. As an example: The construction of a new reservoir to supply the city of Boston is meeting opposition. The State of Connecticut filed a bill of complaint with the Supreme Court during January, 1928, against the Commonwealth of Massachusetts for planning to divert the waters of the tributaries of the Connecticut River—the Swift, Ware and Miller Rivers—from their natural flow into the Connecticut.

Briefly, the State of Connecticut makes the following charges:

(1) The navigability of the Connecticut River would be impaired by any diminution of the natural flow of the river which would result in a flow too slow and sluggish to free the bed from sand bars.

(2) The flood stage would be lowered and the inundation of flood plains which gives the soil its great fertility will be lessened.

(3) The pollution of the stream by Massachusetts and Connecticut industrial plants and city discharges is large, and unless the full flow of the Connecticut is maintained this will not be removed but remain as a detriment to health.

It is expectable that unless the entire area be studied in reference to present and future needs of water, instances of this kind will multiply.

The Case of Los Angeles

Los Angeles, settled in 1781 on the Los Angeles River, obtained from King Carlos III of Spain by royal decree the ownership to all the waters of the river in perpetuity. Until 1914 this was practically its only source of water, and it was considered sufficient to supply a population of 250,000.

When Los Angeles passed the quarter century mark and the Los Angeles River, described as a stream whose bed must be sprinkled regularly to keep down the dust, became inadequate the city tapped the Owens River, 250 miles away. Owens Valley is about 150 miles long, lying between the Sierra Nevada Mountains on the west and the White Mountains on the east. Practically all the drainage is from the Sierra Nevadas between Mt. Lyell and Mt. Whitney. The river empties into Owens Lake, and the latter has no outlet. Previous to 1905 the valley had a population of about 3,500, who gained a livelihood by farming on lands irrigated by the river, since the rainfall of the valley is light—probably not over 5 inches per year.

In areas of limited precipitation, conflicts frequently arise over rights, and it is not strange that, when Los Angeles went beyond her borders for water, trouble followed. The intake of the Los Angeles system on the Owens River was below the headgates of the lowest irrigation ditch,[4] and consequently the city could not deprive the farmers of water, but on the contrary it took at the beginning only such water as would have gone into Owens Lake and eventually evaporated. In reality Los Angeles benefited the Owens Valley farmers by connecting them by rail with the outside market. This boon acted as a boomerang, since it offered inducements to settlers, and the population by 1920 had doubled and a tourist trade had been inaugurated. With this increase in population and a corresponding withdrawal of more water from Owens River by the settlers, Los Angeles found in 1923 that the leavings were not sufficient

[4] "The Owens Valley Controversy." *Outlook*, 146, 341–3, July 3, 1927.

for the city's needs and began to buy land of the farmers to lessen the irrigation drain. Altogether 80 per cent. of the irrigated lands of the valley were purchased. In 1924 there was an outbreak by the farmers, aqueduct waste gates were opened or dynamited and about 200,000,000 gallons of water were turned into the desert.

To-day Los Angeles, beyond the million mark in population, is looking forward to a city of 2,000,000 people and must have more water than can be gained from the Los Angeles and Owens Rivers. She has already surveyed an aqueduct route to the Colorado River—260 miles away—to carry 1,500 seconds feet of water. The Colorado River has not an adequate amount of water for all the requirements of the section. The U. S. Geological Survey estimates that at Parker, when the water is first turned from the river for use, the annual supply will be about 9,593,000 acre feet. Irrigable lands below Parker will demand 9,909,000 acre feet; in Mexico, 3,357,000 acre feet is the probable ultimate need for irrigation; and Los Angeles and other Southern California cities are calling for 2,000 seconds feet, equivalent to 1,448,000 acre feet for domestic purposes: a total of 14,714,000 acre feet—or 4,805,000 acre feet more than is allotted to the Lower Basin of the Colorado River by the Colorado Compact of 1922.[5]

There is some difficulty anticipated in this instance, as in the Owens Valley case, before the Colorado Basin residents yield this amount of water.

The Case of New York City

The domestic water supply in humid regions of dense population is obtained perhaps with greater ease than in arid areas but is beset with difficulties no less acute. New York City's water supply is able to yield 1,100,000,000 gallons of water a day. This water comes from a number of sources: the Catskill system, the latest addition to the city sources, has a maximum of 600,000,000 gallons per day; the Old Croton source of 1842 turns to the city 336,000,000 gallons per day; the Ridgewood system, an extensive underground supply developed on Long Island, adds 90,000,000 gallons per day; old borough sources in operation before their incorporation furnish 30,000,000 gallons per day; and private water companies which still hang over from earlier days are estimated to yield 44,000,000 gallons per day.

The city is using now about 850,000,000 gallons daily. It is estimated that the annual increase in the amount of water is about 31,000,000 gallons daily[6] and if this increase continues for eight years the entire available supply of water will be in use; and within ten years there will be a serious shortage of water. This present condition repeats the history of the water supply of New York beginning with the wells and springs that served 1,500 people in 1664 until late in the year 1915, when the Catskill water was turned into the distributing pipes. Until the Old Croton Dam was constructed (1837–1842) the city was not large enough to demand a water supply from outside her boundaries. The various units of New York's water system represent in part the development of her constituent parts before their union as Greater New York, and in part old contracts by private water companies in the days before public water companies were much in vogue.

At the beginning of the nineteenth century there were in existence 16 waterworks systems in the United States. One of these—Winchester, Virginia—was under public ownership, and the

[5] For a survey of this problem see Robert M. Brown, "The Utilization of the Colorado River," *Geog. Rev.* XVII: 453–466, July, 1927.

[6] C. G. Poore, *New York Times*, xx: 5, Sunday, April 10, 1927.

remaining 15 were privately owned. The percentage of public water plants rapidly increased during the century from 6.3 (1800) to 53.2 (1896).

Only one of the original 16—that of Morristown, N. J.—continues under private ownership. New York's first publicly owned waterworks were constructed in 1830 and yielded 21,000 gallons of water a day. This was an almost insignificant amount in comparison with the Manhattan Company, a private concern, that had a maximum capacity of 700,000 gallons a day. It was however a beginning, and the additions to the water supply were made more and more by the city itself.

In the meantime the boroughs, as they in turn faced the demand for water, developed independent systems of their own.

While New York is built on a rocky island and has therefore a limited water table, Brooklyn is situated on glacial sands and gravels which extend eastward throughout Long Island. The underground water about Brooklyn in 1926 yielded 104,000,000 gallons per day; 73,000,000 gallons of this was taken from wells from 30 to several hundred feet deep; 34,000,000 from infiltration galleries laid for 6 miles 10 to 15 feet below the water table; and in addition Brooklyn received 20,000,000 gallons a day from surface supplies.

New York City covers an area of 315.9 square miles and has an average rainfall of 44.63 inches. If the entire precipitation of an average year over the city was impounded it would amount to 204,125,707,138 gallons or an average of 559,000,000 gallons per day.[7] Only a meager percentage of this is available, since with paved streets the run-off is excessive. The water shed of New York's water system, not counting the Queens and Richmond supplies, is 1,136 square miles—an area equivalent to the State of Rhode Island. This is a little in excess of two square miles for every 10,000 people. The Queens and Richmond areas would probably bring it to three square miles, which is the average amount of drainage space per 10,000 people, utilized by cities dependent on surface water.

For a future addition to her water system there is the proposal to increase the water sheds above the Croton Dam on the east side of the Hudson. This, it is estimated, will add half a billion gallons of water per day to the system and will take care of the increases of population in the city for the next twenty years. There seems to be a little chance to save much from wastage, since the per capita daily consumption in New York (102) is considerably less than any of the other large cities and much below the average for 200 cities (139).

Treatment for Potability, Purity and Industrial Uses

The character of raw water varies greatly. The Great Lakes' waters in their natural state are ideal potable waters, but they are disagreeably polluted by the cities located on them. Topographic conditions at Chicago and Milwaukee compel the cities to dump their sewage, and some of it is untreated, into their sources of water supply. This is overcome partly by placing the intake of the water system far out into the lake—6,565 feet in 67 feet of water for Milwaukee and from 2 to 4 miles off shore for Chicago—and partly by sterilization.

Buffalo has its intake 1¼ miles from shore. Chicago's attempt to settle the problem was to reverse the flow of the Chicago River, but this did not settle the difficulty, for other Illinois towns and neighboring cities continue to contaminate the waters of the lake.

New Orleans has experienced great difficulty with its water supply. Up to

[7] Edward H. Hall, "The Catskill Aqueduct," New York, 1917.

the time the present system was put into operation the city depended in part for its water on cisterns which stored the rain water drained from its roofs, and from a private company which served the raw Mississippi River water. Since 1909 a carefully treated river has been served the city which is advertised as "a clear, pure water of the most desirable quality."

The long journey of the waters of the river from other valley cities which pollute it is in itself a cause of self-purification, and apart from its turbidity—650 parts per million of suspended matter—it is usable.

A few localities are fortunate in obtaining water without treatment, believing with Worcester that "clean water sheds, impounding reservoirs which are kept free from pollution and long storage of water are the best agents for purification."

San Francisco has its water basin carefully excluded from contamination and neither purifies nor filters its supply.

Portland, Oregon, has nothing to pollute its supply, and filtration they claim will never be necessary. New Bedford uses no artificial purification.

The process of cleansing polluted water has reached so high a degree of perfection that almost any raw water may be rendered clear, palatable and safe. An early stage in the process is *sedimentation*. Some of the water used is very turbid. The river water at St. Louis averages 1,430 parts of suspended matter in a million, but the settled water averages but 25 parts; at Atlanta the turbidity runs at times as high as 5,000 parts in a million, but at other times it falls as low as 100; at New Orleans the Mississippi River averages 650 parts; the Missouri at Kansas City 3,100 parts. Lakes to a large degree because of low movement are settling basins and can normally be expected, where not agitated, to have a low turbidity. The Detroit supply is as low as 35 parts per million.

Water with sulphate of lime and magnesia has a permanent hardness that may be reduced a little with difficulty; water with carbonates of calcium and magnesium has a temporary hardness which may be largely eliminated. Hard waters demand a softening process before the proper detergent action of soap can be brought into play. Furthermore, their use in boilers is undesirable because they produce boiler crust and scale by the deposition of the salts present. The Catskill water (New York) is well suited for business and household purposes, for it is very low in iron content and corrosive constituents.[8]

The city authorities sum up the advantages of a soft water: a soft water reduces the use of soap in laundries and in silk dyeing; and affects favorably the operation of power-houses, breweries and photographic establishments. A soft water with low corrosive action eliminates to a great extent scale in boilers and corrosion of tubes, thereby reducing the cost of steam production and the probability of accident. The use of softer waters means the aggregate savings of hundreds of thousands of dollars affecting many classes of consumers in Greater New York.

The Camden water supply board speaks of its soft water in this way: "People taking a bath have here no difficulty in getting soap to lather. In the Middle West it is a hard job."

Within a comparatively brief period of time the water supply of cities has changed from a pestilence bearing medium to an exceedingly pure supply. In Richmond the death-rate from typhoid fever in 1908 was 49.7, and it averaged 59.4 per 100,000 persons for the ten years previous to that date. Settling basins were put into operation

[8] "The Municipal Water Supply System of the City of New York," Dept. of Water Supply, Gas and Electricity. April, 1923.

late in 1908 and in 1909 the death-rate due to this disease fell to 24.1 and averaged during the next 15 years 12.2. In 1924 a filter plant was put into operation, and the death-rate again fell to 5.4 for 1925 and 1.1 for 1926. The typhoid death-rate in Los Angeles for the year ending June 30, 1925, was 1.07 and New York City 2.0. Now New York traces typhoid to oysters, milk, uncooked vegetables and ice cream and to carriers from outside the city, while Los Angeles claims that 50 per cent. of the typhoid fever comes to-day from outside the city. Wilmington, Delaware, following purification processes, reports a 26.9 per cent. reduction in the typhoid death-rate.

The Denver report on its water system says that the death-rate in all cities from typhoid fever is greatly reduced when filter-plants are installed, and that there is a second reduction in the death-rate when the practice of sterilization of the water with chlorine is adopted. The typhoid death-rate in St. Louis per 100,000 persons has diminished from 47 in 1903, 17 in 1913, 4.2 in 1923 to 3.8 in 1924.

Again in Jersey City in 1891, using the Passaic River as its source of water, the typhoid fever death-rate was 101.3 per 100,000; in 1898 from the Pequannock it was 40.6 and 1906 from the untreated Rockaway River, 21.6. In 1913 hypochlorite of lime was used, and the death-rate fell to 10.3, and finally in 1926, following the use of chlorine, it fell to 1.57. New Orleans, which originally used raw water with disastrous results, reported a death-rate for typhoid fever of under 2 per 100,000 persons in 1925. To-day water supplies can be practically absolved as carriers of diseases, and only negligence of the most flagrant character will make the water system of a city dangerous.

Conclusion

Engineering and chemical investigations have subjected raw waters to various processes, so that the quality of water is attaining a high degree of potability. Sedimentation reduces turbidity; sulphates of alum or iron complete this work; filtration removes harmful and undesirable bacteria; chlorination complements filtration; aeration adds oxygen, which eliminates taste and odor due to destroyed bacteria; coppering aids in removing taste; and sulphates of lime and magnesium tend to remove hardness.

Investigations promise in the near future an absolutely tasteless water. Thus the waters of the land may be brought to the household clear, tasteless and sanitary and to the factory soft and clear.

The great problem that remains is the quantity of water in the face of growing populations. Systematic investigation, not of a city's possible resources, but, so that a proper and satisfactory distribution of surface waters may be made without infringement on the rights of others, of the water resources of an extensive area containing many urban groups is the need of the immediate future.

WHENCE OUR METALS?

By NAHUM SABSAY

NEW YORK, N. Y.

WHERE did our gold, silver, platinum, copper, lead, zinc and other metals come from? Why are they found in comparative abundance in some places and not at all in others? Why are metal deposits usually confined to the mountainous regions? And why do they, with few exceptions, always lie in vicinity of, and even in, rocks that were formed by cooling and consolidation of once hot and liquid material?

At present these questions can not be answered with absolute certainty. Geology is no exception to other sciences. It reveals much to the searchers, but it conceals immeasurably more.

However, inadequate as geological knowledge still is to solve the many baffling and often mystifying problems confronting geologists, it is, on the other hand, sufficiently strong to evoke a general picture of the earth's past, and, specifically, the picture of metal deposition.

To begin with, they clearly see that phenomena like the periodic eruptions of Vesuvius, the boiling lava in the crater of Kilauea, the Katmai explosion, the fumeroles of the Valley of Ten Thousand Smokes, the blowing off of Krakatoa, the incandescent dust and gigantic spine of Mt. Pelée, the Icelandic outwellings of lava, the geysers, the hot springs—in short, all the manifestations of the activities of the liquid and hot rock-material within and beneath the crust of the earth—are mere vestiges of the events which in the past geological ages had repeatedly taken place on a staggering scale at and below the surface of the earth.

Time and again during those fabulously removed ages and in place after place inconceivably large masses of highly heated, liquid rock-materials rose from the depths and injected themselves into the earth's crust or, if they reached the surface, spread over it, burying vast areas underneath; creating all kinds of bizarre, phantasmagoric and majestic phenomena; working all kinds of titanic destructions.

Geologists also see that these intrusions and extrusions of the liquid materials are most intimately connected with the formation of the metalliferous deposits and that the beginning of the story of such a deposit is the same as the first part of the story of a nearby intruded mass.

From how far below did these materials, or *magmas*, as they are technically called, come? No one knows. Just as no one knows whether they all came from the same centrally located reservoir or from a number of separate magmatic pools which lay immediately below, or perhaps within, the earth's crust.

Nor does any one know whether magmas, before they rose, were actually liquid or only potentially so, ready to liquefy as soon as favorable conditions were created. Nor does any one know what were exactly the processes of magmatic rising and excavation of the incredibly large crustal chambers which the solidified products of those magmas are now seen to occupy.

The intrusions of magmas and extrusions of *lavas*—as magmas which reach the surface of the earth are called—were mainly confined to the regions where new mountains were being born or where the old ones were undergoing reelevation. Here, where the rocks

were being folded, domed, arched, warped, fractured, displaced, and the whole region was being slowly uplifted to great heights, the magma, or magmas, stored somewhere underneath that region, found the best opportunities to come up, to invade great stretches of rising country, to penetrate its very heart, and thus to bring into it the materials which were to become the core, or cores, of the mountain ranges. Here also these materials found an opportunity to reach the surface through a number of volcanoes and fissures in the crust, to spread over areas of thousands and tens of thousands of square miles and to pile up lava flows hundreds and thousands of feet high.

Those lava flows, as can be seen from their vast remnant, were stupendously large masses of ejected liquid material. Yet when compared with the masses of the material *injected* into the growing mountain ranges, they no longer seem so large. The more or less centrally located, elongated and irregular, subterranean chambers within some of the present ranges—chambers that once were filled with magma but now are occupied by its solidified products—are over a thousand miles long, two or three hundred miles wide, and of unknown depths. And this is not all. Scattered round about these there are other magma-product filled chambers, some small, some large and some immense. Then there are magma-product filled fissures—narrow, wide, short, long—some closely spaced, some spread wide apart, and all together crisscrossing the region in a wide and irregular network. And there are enormous layers of similar product squeezed in between beds of the country rocks and into any other weak zone which the mountain-building processes had produced.

Having injected itself into all those subterranean enclosures, the magma did not remain liquid and hot. It cooled; gave out most of its volatile constituents; crystalized, first partially and then completely; and finally turned into one, or several varieties of the rocks that make up the crust of the earth.

The rate of cooling, crystallization and final consolidation of magma varied, of course, with its mass and its distance from the surface of the earth. When close to the surface and in small enclosures, such as fissures, for instance, the cooling was rapid and the process of crystallization comparatively simple. In the larger chambers and at great depths, magma remained liquid and hot for a long time and in them the process of crystallization was highly complicated, so complicated indeed that it is still but poorly understood. The longer the magma remained liquid and the richer it was in the volatile substances the more it reacted with the surrounding host rocks, often creating in them a number of important and extensive changes, and sometimes altering them completely, thus producing entirely new rocks.

There were a number of factors which influenced the extent and the character of alteration produced by magma in the surrounding country rocks not only from one magmatic chamber to another but also around the periphery of the same chamber. And one of those—and an extremely important one—is the variation in the amount and nature of the volatile constituents which the magma had contained. It is the volatile substances that are mainly responsible for the rock alterations and also for the formation of the metalliferous deposits.

Now what are those volatile substances?

Directly, geologists know very little of them. This is natural since all they can see now of the ancient magmas are the cold and solidified magmatic products, that is, the crystalline rocks, from which all the volatile substances had

gone. And in the country rocks in which a part of those substances were retained, they are no longer what they had once been. Here they combined with some of the constituents of the host-rock and formed a multiplicity of minerals. The rest of the volatile substances had reached the surface, mingled with surface and ground waters and with the atmosphere and thus they are lost for investigation.

Indirectly, however, geologists have a fair conception of what those substances were. They know that most, if not all, of the magmas contained incredibly large amounts of steam or superheated water. They know that many of the magmas contained large quantities of sodium, potassium, chlorine, fluorine, boron, carbon, and a number of other elements. And they believe that some of the magmas carried, in varying proportions, several of the precious, semi-precious, and base metals—gold, silver, copper, lead, zinc, antimony, arsenic, cobalt, nickel, and others—and a prodigious amount of sulphur, in combination with which most of the metals are usually found.

The escape of the volatile substances from the larger magmatic chambers—they went away as gaseous or aqueous solutions, called by geologists *mineralizing* solutions—was a drawn-out affair. While it was going on, the magma, as stated, was slowly cooling, crystallizing, consolidating, cooling still further till it took the temperature of the surrounding rocks. And thus, depending on the chemical composition of the particular magma, the rate of cooling and crystallization, and several other circumstances, some of which are not yet clearly understood and some entirely unknown, one kind or another of the crystalline rocks was formed. Often, by the process of differentiation several of them were produced all from the same magma and even in the same magma-chamber. This is the origin of the *intrusive* or *igneous* rocks—the granites, gabbros, diorites, and nearly two thousand others which all together compose by far the largest part of the *whole* of the earth's crust.

This brings us to the question of the other rocks—the rocks which the magma had intruded, through which it expelled all its enormous quantities of water charged with other volatile substances, and which it often mineralized and sometime enriched with valuable metals. What are those rocks?

In parts these are older igneous rocks which had been formed in still earlier geological ages by other magmatic intrusions. In part these are *extrusive* or *volcanic* rocks like basalt, rhyolite, obsidian, tufa, all formed by cooling and solidification of lavas or by consolidation of volcanic ash. But the most important part of these rocks is of altogether different character and origin. It is composed of *bedded* or *stratified* or *sedimentary* rocks like conglomerates, sandstones, shales, limestones, which were formed by slow accumulation of the sediments on the shores and bottoms of ancient inland seas—seas that existed where these rocks now rise in mountainous masses. And it is through these rocks that the mineralizing solutions most often traveled and deposited in them their mineral load.

All rocks surrounding the magma-filled chamber were usually greatly shattered and fractured by the mountain-building processes and by the injection of the magma. This shattering and fracturing had produced a system of channelways offering the magmatic solutions avenue of escape. If, however, no such channelways were available or were not adequately numerous or large, the solutions, propelled by the high pressure in the magma, took advantage of the porosity of the country rock no matter how minute this porosity was,

and bodily forced their way through it. Often they made use of their ability to dissolve some of the constituents of the country rock, and thus "ate" their way through unfractured and compact rock masses.

No matter what road these solutions took or how devious their courses were or how far they traveled, they eventually mixed with ground waters or came up to the surface where they emerged as springs often still hot—sometimes as steam—and still mineralized. And thus they added a new supply of water to that which had existed in the ground and at the surface—a supply which till then was locked in the bowels of the earth and had taken no part in the perpetual circulation of the ground, surface and atmospheric waters.

Only, upon issuing at the surface, the solutions were different from what they had been when they parted from the parental magma. They were much cooler, greatly impoverished in the mineral content, and whatever mineral substances they still retained were mostly derived not from the magma but from the country rocks.

What did they do with the other substances? Where did they leave them?

They dropped them. Dropped them in the form of various minerals. Dropped them partly here, partly there, sometimes all in one place, sometimes scattered far and wide, sometimes close to the magma, sometimes far from it both vertically and laterally, sometimes near the then earth's surface, sometimes at great depths. They dropped them wherever favorable conditions were met or wherever they were forced to do so. They dropped them in open fissures and in any other open space they happened to be passing through, filling and sealing them completely. And they had left them in the massive rocks in exchange for other mineral substances which those rocks were willing to give up.

And if in the original load there were some of the valuable metals, these, too, were dropped. And if the solutions did not scatter these metals, but tucked them away within comparatively small spaces, then valuable ore bodies resulted.

It is seldom possible to tell exactly why the solutions chose the particular area in the magmatic chamber to escape through; the particular distance from it to deposit part or the whole of their load; the particular horizon; the particular rock; the particular zone in that rock. In fact, the entire behavior of the mineralizing solutions at times seems to be extremely capricious. They are known to have repeatedly played many a strange and unexpected trick which now perplexes geologists when they try to reestablish the course these solutions followed and the affinities they exhibited towards the various rocks.

What was the time consumed by the expulsion of all the volatile constituents of the magma and by the cooling and solidification? This question geologists must answer with many reservations, and even then only in a general way.

They think that in the fissures and other small enclosures which lay close to the surface, the cooling and solidification were accomplished within a few weeks and months from the time the injections were completed. They believe that here the crystallization was comparatively a simple process. For the cooling and solidification of the magma in the larger chambers and in those that lay far below the contemporary surface, they think tens of years must have been necessary and that correspondingly, the process of crystallization was here much more complicated. And they think that it required hundreds and thousands of years to turn into solid rock all the magma that now constitutes the core of the large mountains. This is about all geologists can say regarding

the duration of the cooling and crystallizing processes. They might add, however, that long as the expulsion of the magmatic solutions and the mineralization of the country rock might seem when regarded in terms of human life, the mineralizing process, when compared with the entire duration of the birth and growth of the mountains, seems a fleeting moment merely.

With the injection of the magma or magmas into the growing mountains, the folding, arching and fracturing of the rocks did not end. The disturbances continued. The history of the mountains was still in the making. It has never ceased to be. And it is with the post-intrusion history of the mountains that the history of the newly formed metalliferous deposits becomes from now on most closely connected.

The continued uplifting sometimes of the whole region, sometimes of only local new injections of magmas, new volcanic eruptions, new arching, folding, doming broke up the rocks into large and small blocks often cutting across the newly formed or previously existing ore bodies. This was followed by new readjustment of rock blocks; new slidings of one past the other; some moving upwards, some downwards, some sidewise; moving into all possible directions for all kinds of distances. It was thus that many an ore body became cut up into pieces and the various parts widely separated from each other. And it was thus that occasionally the whole ore body with the enclosing country rock was moved far away from its original position.

Meanwhile an entirely different kind of activity was going on above, at the surface. Heat, frost, atmospheric waters, plants, burrowing animals, acids of the soil were tirelessly and ceaselessly attacking the exposed rocks, eroding them away, carving them into peaks, ridges, cliffs, valleys, canyons, gorges. At the same time the rainfall, winds, streams were washing down the fine and coarse débris, transporting them to the inland seas where currents and waves assorted them, spread them out and deposited them in alternating beds of graded material. Here these beds have often accumulated to thousands upon thousands of feet in total thickness and consolidated under the enormous pressure of the overlaying layers, thus forming series of sedimentary rocks. In time these seas had drained, the newly formed rocks uplifted, and either remained as the more or less flat veneer that constitutes nearly everywhere the upper part of the land's crust or were raised higher and folded into mountains and highlands which in turn were intruded by magmas and capped by lavas, and sometimes enriched by valuable minerals. And the cycle continued.

But to return to the ore bodies which we left somewhere below the surface of the mountain which is undergoing erosion.

As the erosion proceeded deeper and deeper, the top of now one or another of the ore bodies became exposed and, as the erosion proceeded still farther, the ore minerals, the mixed-in-with-them, valueless minerals—the *gangue*—and the surrounding country rocks also became gradually disintegrated.

The disintegration of the metallic minerals freed great quantities of sulphur with which, as already stated, most of the metals were or had been combined. The freed sulphur, uniting with oxygen of the air and with the ground and atmospheric waters, formed weak solutions of sulphuric acid and these dissolved the metals. These new metal-bearing solutions either carried the metals lower down where they enriched the still undecomposed metallic minerals, or dropped them in other

places where favorable conditions for deposition existed, or mingled them with the circulating ground waters and thus frittered away great wealth. Even in the first two cases the saving of the metals was only temporary. Eventually the erosion reached the enriched and redeposited metals—these are called *secondary* deposits—disintegrated them also and carried away their metals to some other region, to the rivers, seas and oceans.

Many of the ore deposits were thus completely destroyed in the past geological ages. Some of them were still undergoing destruction when man appeared on earth. In time, these deposits, too, would have been completely lost had not man learned the uses of the metals, learned how to mine them and how to extract the metals from the worthless ingredients.

By now nearly all the deposits which the erosion of the earth's surface had uncovered have been located except, of course, those which still might be found in the little known parts of the world. Most of the high and fairly high-grade deposits located, both those which outcrop at the surface and those which lay at some distance below it and had been discovered by underground explorations, are very well worked out and many entirely exhausted. And while it is true that there still remain a great many of the low-grade deposits of which only, comparatively, a few are mined, the mining of most of those is at present not a profitable affair. It is for the still hidden rich ore bodies—ore bodies which may lie almost any place in the mineralized and ore-bearing regions and give no intelligible signs of their whereabouts—that mining engineers and geologists are eagerly searching. And the search for these is a long, laborious, expensive, and, above all, uncertain and precarious task.

INSECTS IN ENGLISH POETRY

By PEARL FAULKNER (Mrs. C. O.) EDDY

CLEMSON COLLEGE, S. C.

(Continued from the July issue)

In praise of Erinna, the little maid who followed so closely in Sappho's tread, some one says:

This is Erinna's honeycomb, though small
'Tis of the Muses' sweets commingled all;
Three hundred lines that match with Homer's lays:
Such power this maid of nineteen years displays.
—*Anon., "Greek Anthology," Collins.*

Shelley claims that his song "drooped," but certainly those notes in which he sounds his lament soar into the rarefied atmosphere of high excellence, where the fluttering wings of an ephemeral insect keep them far above the plains of mediocrity.

As a far taper fades with fading night,
As a brief insect dies with dying day,
My song, its pinions disarrayed of might,
Drooped:
—*Shelley, "Ode to Liberty," XIX.*

The Teacher

Throughout the ages, the voice of the reformer, whether emanating from the throat of poet or priest, prophet or king, or arising in a chorus from the people, has reiterated Solomon's admonition: "Go to the ant, thou sluggard; consider her ways, and be wise."[61] Lacking the harshness of the Hebrew man of wisdom, one hears a voice from the "Old English Miscellany" exhorting, "Let us imitate, then, this little creature, and on doomsday we shall not have cause for sorrow."

In a fable of gentle tone but unmistakable intent, Aesop tells the story of the futile attempt of the grasshopper to divert the ant from her labors by an invitation to chat. In the winter the grasshopper, dying of hunger, has learned too late that "It is best to prepare for the days of necessity."

Allan Ramsay completely overthrows the *status quo* of the ant, making her the flippant offender, priding herself upon being "made wi' better grace" than the clumsy caterpillar that she disdains as "some experiment o' Nature." When next they chance to meet the caterpillar has become a butterfly and proffers to the ant the following bit of advice:

Inferiors ne'er too much despise,
For fortune may gie sic a turn,
To raise aboon ye what ye scorn:
For instance, now I spread my wing
In air, while you're a creeping thing.
—*Allan Ramsay, "The Caterpillar and the Ant."*

O. Henry, with a daring irreverence for her traditionary position, mocks the ant as a "silly creature," lacking judgment and discretionary power and merely following blindly an established custom, not departing from the beaten track enough to avoid an obstacle.

The ant by no means monopolizes the attention of the reformer. In Bacon's essay "Of Vain-Glory" occurs the pertinent statement: "It was prettily devised of Aesop: The fly sat upon the axle-tree of the chariot wheel, and said, 'What a dust do I raise!'" Though attributed to Aesop, this story occurs in the "Fables of Laurentius Abstemius." The bald man, usually a stock subject for humorists in his painful attempts to swat the bothersome fly, sometimes becomes a wiser man, evoking admiration rather than ridicule. Such a man disregards the fly when he returns to the attack, and, with the stoicism of a Spartan hero, is able to

[61] Proverbs, VI: 6.

philosophize: "You will only injure yourself if you take notice of despicable enemies."

In his "Essay on Man" Pope makes a very comprehensive summary of the evils of mankind, and is correspondingly inclusive in the remedies he prescribes.

Go, from the creatures thy instructions take:
. . . . . .
Thy arts of building from the bee receive;
Learn of the mole to plough, the worm to weave;
. . . . . .
Here too all forms of social union find,
And hence let Reason late instruct mankind.
Here subterranean works and cities see;
There towns aërial on the waving tree;
Learn each small people's genius, policies,
The ants' republic, and the realm of bees;
How those in common all their wealth bestow,
And anarchy without confusion know;
And these for ever, tho' a monarch reign,
Their sep'rate cells and properties maintain,
Mark what unvaried laws preserve each state,
Laws wise as Nature, and as fix'd as Fate.

Pope was probably influenced in his recommendations by the famous passage of Shakespeare, in which he commends the government of the bees:

. . . Therefore doth heaven divide
The state of man in divers functions,
Setting endeavour in continual motion;
To which is fixed, as an aim or butt,
Obedience: for so work the honey bees;
Creatures that, by a rule in nature, teach
The act of order to a peopled kingdom.
They have a king, and officers of sorts:
Where some, like magistrates, correct at home;
Others, like merchants, venture trade abroad;
Others, like soldiers, armed in their stings,
Make boot upon the summer's velvet buds;
Which pillage they with merry march bring home
To the tent-royal of their emperor:
Who, busied, in his majesty, surveys
The singing masons building roofs of gold;
The civil citizens kneading up the honey;
The poor mechanic porters crowding in
Their heavy burdens at his narrow gate;
The sad-ey'd justice, with his surly hum,
Delivering o'er to executors pale
The lazy yawning drone.
—*Shakespeare, "Henry V," I: 2.*

The insects have proved themselves such successful teachers that many of their lessons have become a part of the general knowledge of the people, who learn them as proverbs to govern their conduct. The people learn not only from the wisdom of insects but profit by the example of their folly. Bees with their complex social life have supplied a greater variety of precepts and axioms than any other insect.

The adage, "What's good for the bee is good for the hive," or stated negatively, "What is not good for the bee is not good for the hive,"[62] seems to indicate that long ago the bees settled the question of individualism versus socialism.

Men, with perseverance, might be included in the company in which woman is placed when she is criticized as stubborn! "Swine, women, and bees can not be turned."[62]

Perhaps in an effort to remember the details of his bee culture, the apiarist learned proverbs as one attempts to recall the number of days in each month by repeating a rhyme.

A swarm of bees in May is worth a load of hay;
But a swarm in July is not worth a fly.
—*Benham, "Book of Quotations."*

For one bee wanting who will burn the hive?
—*Scuman O'Sullivan, "Virginibus Puerisque."*

When bees are old they yield no honey.
—*Benham, "Book of Quotations."*

"A dead bee maketh no honey" is placed in George Herbert's collection of "Outlandish Proverbs" and if it ever served a practical purpose, nothing remains to testify to its usefulness.

Many distinctly different lessons may be drawn from the fly.

'Tis eminence makes envy rise,
As fairest fruits attract the flies.
—*Swift, "To Dr. Delaney."*

The fly that sips treacle is lost in the sweets.
—*Gay, "Beggar's Opera."*

Dead flies cause the ointment of the apothecary to send forth a stinking savour: so doth a little

[62] Benham, "Book of Quotations."

folly him that is in reputation for wisdom and honour.

—*Ecclesiastes, 10: 1.*

Some version of the Eastern proverb, "You will catch more flies with a spoonful of honey than with a cask of vinegar," occurs in most languages.

Suggestive of Solomon's lesson of the "lilies of the field" is:

Let me dress as fine as I will,
Flies, worms, and flowers exceed me still.
—*I. Watts, "Against Pride."*

Teaching temperance, is the advice: "Hast thou found honey? Eat so much as is sufficient for thee, lest thou be filled therewith, and vomit it."[63]

To the statement, "Haste makes waste," there is the proverbial exception which in the Russian language becomes "Hurry is good only for catching flies,"[64] or in another proverb "Nothing in haste but catching fleas,"[64] and in the Italian, which lengthens the list, "Nothing is done well in haste except running from the plague and quarrels, and catching fleas."[64]

The familiar desire to "kill two birds with one stone" is also rendered "kill two flies with one flap."[64]

Expressing opposite situations are the axioms: "To a boiling pot flies come not"[65] and "As worms are bred in a stagnant pool, so are evil thoughts in idleness."[64] Likewise, "Flies are busiest about lean horses."[64]

Sharing the popularity of proverbs are the aphoristic expressions descriptive of temper. "A fly has stung you"[64] when you are piqued; when you are wrathful you are as "mad as a hornet." The severity of the sting of the wasp or the hornet renders the adage to "stir up a hornet's nest" or to "put one's hand into a wasp nest" equally forceful in expressing troublesome, perplexing situations. When a man has an idea "He has a bee in his bonnet lug,"[66] and when he has a hint, he "has a flea in his ear."

Sad but all too true are the following conclusions of the sages:

Ants never make for empty storehouses; no friend makes his way toward ruined fortunes.
—*Ovid, "Tristia," Bk. 1: 9.*

What the reason of the ant laboriously drags into a heap, the wind of accident will collect in one breath.
—*Schiller, "Fiesco," 11: 4.*

You must lose a fly to catch a trout.
—*Benham, "Quotations."*

Fiddlers' dogs and flies come to the feast unasked.
—*Benham, "Quotations."*

The recurrence of a proverbial expression and its adaption to very different ideas in literature may be illustrated by the following quotations, based upon the well-known adage, "Tread on a worm and it will turn." (In the Latin the same idea is rendered, "Even the fly has a spleen," or in the Greek, "Even the ant and the worm have their wrath.")

. . . Never one
Humbled himself before, as I have done—
Even the instinctive worm on which we tread
Turns, though it wound not—then with prostrate head
Sinks in the dust and writhes like me—and dies.
—*Shelley, "Julian and Maddalo."*

Who 'scapes the lurking serpent's mortal sting?
Not he that sets his foot upon her back.
The smallest worm will turn, being trodden on.
—*Shakespeare, "Henry VI," Part III, II: 2.*

Man spurns the worm, but pauses ere he wake
The slumbering venom of the folded snake:
The first may turn, but not avenge the blow;
The last expires, but leaves no living foe.
—*Byron, "Corsair," Canto 1.*

I am all but sure my dagger was a feint
Till the worm turn'd—not life shot up in blood,
But death drawn in;—(looking at the vial) this was no feint.
—*Tennyson, "Becket," IV: 2.*

[63] Proverbs, 25: 16.
[64] Benham, "Book of Quotations."
[65] Herbert, "Jacula Prudentum."
[66] Lily, "Euphues or the Anatomy of Wit."

Though man has traveled along the path of civilization for many centuries from the time of Solomon, he is still admonished by the most famous exponents of the age to go to the insect for wisdom. Poor man has proved himself a dull pupil, but in extenuation of his reluctance to heed the voice of the reformer, the scientist is about to convince him that fundamentally his insect models, whether performing exemplary or foolish acts, in reality deserve neither praise nor blame, being but mechanical followers of instinctive impulses.

Though the poet may not continue to praise the morals of the ant or the policies of the bees, he may still send man to the insect that, whether artist or artisan, works with matchless skill. He still may learn from

> . . . millions of spinning worms,
> That in their green shops weave the smooth-haired silk,
> —*Milton, "Comus."*

and from

> . . . the black wasp's cunning way,
> Mason of his walls of clay,
> And the architectural plans
> Of grey hornet artisans–
> —*John Greenleaf Whittier, "The Barefoot Boy."*

Rivaling in efficiency man's most modern machinery, the wood borers drill holes into hard woods, or carve out a system of tunnels more complicated than the New York subways. If man could construct machinery on a scale suitable for his use, as efficient as that of these little models, he could burrow into the earth for hidden treasure, perfect national waterways and airways at a pace that would offset the many delays caused by the slowly moving wheels of his legislative machinery. Long years with their heavy toll of lives must pass before man develops a technic of flying comparable to that of the winged insect that may outstrip the most daring "stunt" flyer, jump without a parachute, and glide to a safe landing in any field.

The Satirist

Goliath, with premature scorn, rings out the challenge to the enemy:

> Bid any little flea ye have come forth
> And wince at death upon my finger-nail!
> —*De La Mare, "Goliath."*

David, volunteering, vanquishes the giant and thereupon is so highly praised that the jealousy of his king is aroused. David then proves himself to be not only an ingenious warrior but a clever diplomat, diverting Saul's attack by saying: "Now, therefore, let not my blood fall to the earth before the face of the Lord: for the king of Israel is come out to seek a flea as when one doth hunt a partridge in the mountains"—*I Samuel, 26: 20.*

Though engaging in the more gentle combat of hearts, a king becomes, in the eyes of an unsympathetic friend, a mere gnat.

> O, what a scene of foolery I have seen,
> Of sighs, of groans, of sorrow, and of teen!
> O me, with what strict patience have I sat
> To see a king transformed to a gnat!
> —*Shakespeare, "Love's Labor's Lost," IV: 3.*

The flea does heavy service for the satirist, hopping to his aid when he is angry or disgusted with giant, king or coward. A mollycoddle is said to "have no more man's blood in's belly than will sup a flea."[67] The liver also becomes the seat of bravery. "If he were opened, and you find so much blood in his liver as will clog the foot of a flea, I'll eat the rest of the anatomy."[68]

With something of the air of a professional trainer intoning the accomplishments of his remarkable little performers, Shakespeare pompously recites:

> That's a valiant flea that dare eat his breakfast on the lip of a lion.
> —*Shakespeare, "Henry VIII," 6.*

[67] Shakespeare, "Love's Labor's Lost," IV: 3.

[68] Shakespeare, "Twelfth Night," III: 2.

Pope, in his gallery of undesirables, derisively pronounced every one a worm. This large gallery, including types ranging from fops and beaux to misers and physicians, almost exhausts the poet's catalogue of worms.

The wrath of the poet is vented upon those who infringe upon his creations. Pope, in stinging phrases, denounces Sporus:

Next o'er his books his eyes began to roll,
In pleasing memory of all he stole,
How here he sipp'd, how there he plunder'd snug,
And suck'd all o'er, like an industrious bug.
—*Pope, "Dunciad," Bk. 1.*

The superparasitism of insects becomes analogous in the biting satire of Swift, to plagiarists, the thieves who in turn become victims of other thieves, among whom there is no honor.

So, naturalists observe, a flea
Has smaller fleas that on him prey;
And these have smaller still to bite 'em,
And so proceed *ad infinitum.*
Thus every poet in his kind
Is bit by him that comes behind.
—*Swift, "A Rhapsody."*

The insect is featured in satirization of style, as well as content of verse.

Now hints, like spawn, scarce quick in embryo lie,
How new-born nonsense first is taught to cry,
Maggots, half-form'd, in rhyme exactly meet,
And learn to crawl upon poetic feet.
—*Pope, "Dunciad," I: 61.*

Wolcot, joining in the chorus of those who decry the famous Dr. Samuel Johnson, designates his as a

. . . turgid style,
That gives an inch the importance of a mile,
Casts of manure a wagon-load around
To raise a simple daisy from the ground;
Uplifts the club of Hercules, for what?
To crush a butterfly or brain a gnat.
—*Wolcot, "On Dr. S. Johnson."*

Readers who are secretly pleased to see fleas and gnats jumping from one baffling writer to another, should not rejoice too soon. A stray insect, desiring a change of diet, may alight upon the stupid reader and take an ample bite. However, if an anesthesia of humor is applied, the victim can feel no stinging pain, though the operation be a great surgical feat. Burns administers an anesthetic when he discovers a copy of Shakespeare, "splendidly bound, but unread, and much worm-eaten."

Through and through th' inspir'd leaves,
Ye maggots, make your windings;
But oh! respect his lordship's taste,
And spare the golden bindings.
—*Burns, "The Book-Worms."*

Simile and Metaphor

Personal characteristics are well described in terms of insects. Hair "like the wild bee's honey,"[69] eyes "like glowworms,"[70] and "fingers as busy as bees"[71] appear incongruous in the picture of a woman "nakid as a worme."[72] However, when each is viewed properly, the effect may be a lovely picture of a Saxon maiden's

. . . curls streaming flaxen-golden,
By the misted moonbeams kist,
Dispread their filmy floating silk
Like honey steeped in milk.
—*F. Thompson, "Sister Songs."*

The genius of the poet in selecting and combining appropriate ideas is nowhere more apparent than in the similes that add richness and beauty when fittingly chosen but distort and mar when misplaced.

Anatomically man, by a consolidation of poetic ideas, becomes a living insectary. The lover, who so adroitly changes himself into a bee, in the effusiveness of his ardor transforms hands that steal his honey into wasps.

O hateful hands to tear such loving words—
Injurious wasps! to feed on such sweet honey,
And kill the bees that yield it with your sting!
—*Shakespeare, "Two Gentlemen of Verona."*

[69] Masefield, "Third Mate."
[70] Shakespeare, "Venus and Adonis."
[71] Wordsworth, "Farmer of Tilsbury Vale."
[72] Chaucer, "Romaunt of the Rose."

The smile, voice and face of the adventuress are "all subtle flies to trouble man the trout,"[73] but the eyes of a faithful maid are "wild brown bees"[74] stinging her lover with a charming opiate.

In humility the psalmist says, "I am a worm, and no man";[75] and Tennyson, in the despair engendered of civil strife, prays:

Strike dead the whole weak race of venomous worms,
That sting each other here in the dust;
We are not worthy to live.
—*Tennyson, "Maud," III.*

But corrupt worms, the worthiest men.
—*Donne, "A Fever."*

Those who live parasitically are generally denounced as drones robbing the producers, the bees, of their honey. Idle courtiers are "gilded flies,"[76] misers hoarding the wealth of the land are "drones that rob the bee of her honey."[77] With equal aptitude insurrectionists are termed "caterpillars of the commonwealth."[78] Drone, though the most common, is not the only insect appellation given the thief.

In thy weak hive a wandering wasp hath crept,
And suck'd the honey which thy chaste bee kept.
—*Shakespeare, "Lucrece."*

Othello laments the probability of being left behind "a moth of peace"[79] when the war is raging, but those who enlist as soldiers become "mortal bugs o' the field."[80]

Bees, usually praised collectively and individually as an example for personal or national emulation, in at least one instance become synonymous with the undesirable citizens, who are a "scandalous hive of those wild bees."[81] In no case, however, are the drones regarded favorably. Poets of the future may come to the rescue of the drone in view of his defense by contemporary scientists who accord to him the important function of the propagation of the species.

People seeking favoritism from the great or basking in the reflected glory of the famous are aptly designated as flies "that ever swarm about—the highest heads."[82] The irony of these pseudo-hero worshippers is implied in Hamlet's pertinent injunction—"The great man down, you mark his favorite flies."[83]

When a flippant, frivolous, ornate, character, rather than one deliberately parasitic, is depicted, the butterfly supersedes the drone as a metaphor.

A mere court butterfly,
That flutters in the pageant of a monarch.
—*Byron, "Sardanapalus," V: 1.*

Fops are painted butterflies.
—*Pope, "To Mr. John Moore."*

The sports world honors its champions by giving them insect names. Football, baseball and basketball teams have been cheered to victory by lusty insects, especially "Hornets" and "Yellow-jackets," flying from the vociferous tongues of thousands of grandstand fans.

Those who win their wings and fly as new adventurers into that element so long ruled only by insect and bird have a fondness for fancying themselves and their craft insects or birds. The English girl who christened her plane the "Gipsy Moth" and made the long flight to Australia revealed a poet's imagination as well as an adventurer's daring.

Many pleasing little studies in contrasts may be made to show the enormous versatility of insects. In a pledge of allegiance, soldiers promise to follow "like stinging bees in hottest summer's

[73] Masefield, "Widow of Bye Street."
[74] F. Thompson, "Unto the Last."
[75] Psalms, 22: 6.
[76] Shelley, "Queen Mab."
[77] Shakespeare, "Pericles," II: 1.
[78] Shakespeare, "Richard II," II: 3.
[79] Shakespeare, "Othello," I: 3.
[80] Shakespeare, "Cymbeline," V: 3.
[81] Tennyson, "The Holy Grail."
[82] Tennyson, "Columbus."
[83] Shakespeare, "Hamlet," III, 2.

day."[84] If fate decrees failure instead of success, they flee "like insect tribes before the northern gale."[85]

Dressed in colorful silks, people are as "rich as moths from dusk cocoons,"[86] or the poet, with "robe and wreath" cast off is "like the tattered wing of a musty moth."[87] As bedraggled finery is more forlorn than threadbare rags, so a rich moth with a "tattered wing" is a more striking example of an impoverished state than a nondescript shrivelled fly.

The poet may be as busy as the proverbial bee or as "weak as a rained-on bee."[88]

Alacrity and slowness of action are contrasted by insect motions. A man "with a lancet quick as flies"[89] darts to an encounter, or moments crawl "like last year's flies."[90]

Joy is like a "summer fly,"[91] but "as motthes in the shepes flees anoyeth to the clothes, and the smale wormes to the tree, right so anoyeth sorwe to the herte."[92]

"Sweet thoughts" swarm "as bees about their queen,"[93] but "restless thoughts" are like a swarm "of hornets armed."[94]

People in many situations are comparable to insects. An enormous crowd at a fair congregate "like blowflies to the roast,"[95] and the gatherings at a theater are "like ants on molehills" or "bees to hives."[96] The Biblical analogy finds similarity between the advancing hosts from the enemy camp who are "as grasshoppers for multitude," an impressive comparison suggestive not only of great numbers but of destructive forces reminiscent of the plague, sent by special dispensation of providence for their punishment. Multitudes of the enemy are variously described as being as numerous as the cankerworms, the locusts or the caterpillars.

While hosts are comparable to insect swarms, a solitary individual may be likened with striking effect to a single insect. The disconsolate "Tess of the D'Urbervilles" was "like a fly on a billiard table of indefinite length."

Rejoicing or sorrowing, man has been likened unto insects. The old chieftains of the Iliad, retelling tales of war, "like grasshoppers rejoice,"[97] and Longfellow refers to the same famed men as "chirping like grasshoppers."[98] Conrad in a masterful prose has attained poetic results in such images as that in which he fancies the "soul writhing in his body like an impaled worm," or as that of the tortured Lord Jim "Squirming like an impaled beetle."

By no means all insect appellations are employed in a derogatory sense. Frequently terms of highest praise are voiced in complimentary attributes of insects. The bee, as previously observed, is a general synonym for the worthy citizen. It also is widely used in reference to the individual. A woman of domestic type is praised as the rare "household honey-making bee, Man's help!"[99] As a tribute to a true but unrecognized poet, Browning says: "My star, God's glow-worm."[100] In an epilogue to his sister, Francis Thompson calls her

"Bird of the sun! the stars' wild honey-bee!"

Metaphorically varied types of people and things become insects. The situation is frequently reversed and insects are transformed into people, souls or

[84] Shakespeare, "T. Adron.," V: 1.
[85] Shelley, "Revolt in Islam."
[86] Tennyson, "The Princess."
[87] F. Thompson, "Judgment in Heaven."
[88] Torrence, "Eye-Witness."
[89] Masefield, "Everlasting Mercy."
[90] A. Lowell, "Bird and Tree."
[91] Wordsworth, "Mother's Return."
[92] Chaucer, "Tale of Melibeus."
[93] Tennyson, "The Princess."
[94] Milton, "Samson Agonistes."
[95] Masefield, "Widow in Bye Street."
[96] Dryden, From Ovid, "Art of Love."
[97] Homer, "Iliad," Pope, 3.
[98] Longfellow, "Morituri Salutamis."
[99] Tennyson, "Becket," V: 2.
[100] Browning, "Popularity."

even gods. The butterfly is entreated by Wordsworth to remain as the "historian" of his infancy. Butterflies may be "gay triflers"[101] or "pretty genii of the flow'rs."[102] Moths are "daughters of the air."[103] The bee is "nature's confectioner," the "almsmen of spring-bowers"[104] or, most charmingly a reincarnated god sipping the nectar of the rose.

When entrapped, man is easily regarded as an insect caught in a spider web. "With as little a web as this will I ensnare as great a fly as Cassio."[105] Jim, ensnared by his mistress' wiles, becomes "a fly in Anna's subtle weavings."[106] Vivien playfully indulged her fancy as she drew

> The vast and shaggy mantle of his beard
> Across her neck and bosom to her knee,
> And call'd herself a gilded summer fly
> Caught in a great old tyrant spider's web.
> —*Tennyson, "Merlin and Vivien."*

The worm is perhaps most frequently chosen for the expression of abstract qualities. The worm described as a clumsy, creeping thing proves himself one of the most versatile literary insects. Man, his life and passions, his sins and his eternal punishment are analogous to various kinds of worms. In distress a person is a "poor twisting worm."[107] The malicious are scorned by the knightly who are "wroth to be wroth at such a worm."[108] Man, the worm, during the whole of his life is subject to "error, the worm,"[109] and is "tettered with worms of fear."[110] If he frees himself from error, pride creeps in "and swells a haughty worm."[111] From his brief respite comes

> Pain, that has crawl'd from the corpse of
> Pleasure, a worm which writhes all day, and
> at night
> Stirs up again in the heart of the sleeper,
> And stings him back to the curse of the
> light;
> —*Tennyson, "Vastness," IX.*

Failing to attain his heart's desire, man has lasting regret.

> The worm, regret, will canker on
> And Time will turn him never.
> —*Henley, "Echoes."*

When he sins, man is gnawed by the "worm of conscience."[112] Finally the worm, death, conquers him. Though his body be devoured by worms, his soul, if consigned to hell, is eternally preyed upon by "Shame that stings sharpest of the worms in hell,"[113] and "giant worms of fire forever yawn."[114] If he is righteous, though "The mortal worm might make the sleep eternal,"[115] his soul will leave his body as a butterfly leaving the chrysalis, and dwell eternally in a place "where the charm'd worm of pain shall gnaw no more."[116]

Various political and military features of government furnish many occasions on which the poet may express his social or patriotic ideas, sometimes calling forth expressions of highest praise and again his most scathing denunciation. The insect flies more often into the latter. Politics, covering such an extensive area of corruption, include the bee, otherwise an object of emulation.

> But bees on flowers alighting, cease their hum,
> So, settling upon places Whigs grow dumb.
> —*Thomas Moore, "Corruption."*

Without losing any of its perspicacity, the statement of an ancient sage regarding laws might be repeated to-day. "One of the Seven was wont to say: That laws were like cobwebs; where the

101 Heine, "Holland's Butterfly Book."
102 Hood.
103 Fontaine, "Moth Book."
104 Keats, "Isabella," 13.
105 Shakespeare, "Othello," II: 1.
106 Masefield, "Widow in Bye Street."
107 Watts, "Sincere Praise."
108 Tennyson, "Geraint."
109 Shelley, "Epipsychidion."
110 De La Mare, "Gloria Mundi."
111 Meredith, "Modern Love."
112 Shakespeare, "Richard III," I: 3.
113 Swinburne, "Marino Faliero."
114 Shelley, "Revolt of Islam," 37.
115 Shakespeare, "2 Henry VI," III: 2.
116 Wordsworth, "Descriptive Sketches."

small flies were caught, and the great break through."—*Bacon, "Apothegms," No. 8.*

In "The Prophyce of Famine" Churchill laments the fact that

There webs were spread of more than common size,
And half-starved spiders prey'd on half-starved flies.

Burke, in a masterpiece of forensic discourse, features grasshoppers in his "Reflections on the Revolution in France."

Because half-a-dozen grasshoppers under a fern make the field ring with their importunate chink, whilst thousands of great cattle reposed beneath the shadow of the British oak, chew the cud and are silent, prey do not imagine that those who make the noise are the only inhabitants of the field; that of course they are many in number; or that, after all, they are other than the little shrivelled, meagre, hopping, though loud and troublesome insects of the hour.

A few revolutionists are grasshoppers; the entire army of the enemy are "ant-born."

Fly then, ill-manner'd, to thy native land,
And there thy ant-born Myrmidons command.
—*Homer, "Iliad" Bk. 1.*

Attitude

The general attitude of poets toward insects may be inferred from their treatment of them in poetry. Some poets, however, take the trouble to express a direct opinion. While insects are highly specialized in their work, they are just the opposite in their effect on people. Insects are chameleons changing their color to blend with the tones of the poet's mood. Insects which are exactly alike will be exalted by one, denounced by another, and even the same poet will characterize the same insect at one time as divine and at another as vile, depending upon the mood of the moment.

Man, naturally regarding all life from the anthropomorphic standpoint, is inclined to consider the insect good or evil as it affects him favorably or unfavorably. Those insects that delight his eye or those that commend themselves for their industry easily fit into favorable places in the poet's writings.

When insects appear in such numbers as to destroy crops or to constitute a plague of any kind, one hardly expects the altruistic attitude to predominate. Even then the sympathetic Shelley ("Sensitive Plant") says their intent "Although they did ill, was innocent."

Personal parasites, preying upon the body of an individual, would seemingly be the last to appeal to the sympathy of the poet. Bryant, however, shows an unusual willingness to heed the voice of a hungry mosquito.

Fair insect! that, with threadlike legs spread out,
And blood-extracting bill and filmy wing,
Dost murmur, as thou slowly sail'st about,
In pitiless ears full many a plaintive thing,
And tell how little our large veins would bleed,
Would we but yield them to thy bitter need.

Certainly no more than cold hospitality could be expected of the poet who suddenly finds himself host to insect guests, that, uninvited, come to make a stay of doubtful length. When the poet's neighbor becomes host instead, it is easier to sympathize with the guests who are accorded no welcome at all. Burns, when he began talking "To a Louse" visiting a pretentious neighbor, apparently thinks the lowly guest should not have come to such a high place, but when he remembers the haughty airs of the neighbor he is secretly pleased that she is to be embarrassed by the arrival of a disreputable guest.

Ha! where ye gaun, ye crawlin' ferlie?
Your impudence protects you sairly:
I canna say but ye strunt rarely
Owre gauze and lace:
Though faith, I fear ye dine but sparely
On sic a place.

. . . . .

Oh wad some power the giftie gie us
To see ourscls as others see us!

It wad frae monie a blunder free us,
And foolish notion:
What airs in dress and gait wad lea'e us,
And even devotion!

The gadfly that stung Pegasus and brought the ambitious Bellerophon crashing to earth, is not the only insect that has circumvented man's journey to heaven. Even Wordsworth lost his temper when "tormented by the stings" of insects, and Michael spent the day "cursing the flies and heat."[117]

The fly, generally regarded as a pest, perhaps best illustrates the broad sympathies of the poets who can lose sight of their personality and identify themselves with the insect. Kindly, tolerant Uncle Toby released a fly he had caught with the words: "Go, poor devil, get thee gone! Why should I hurt thee? This world surely is wide enough to hold both thee and me."[118] Oldys, remembering the short life of the fly, thinks of his own fleeting existence, and in sympathy, as to a fellow creature, offers the invitation:

Busy, curious, thirsty fly,
Drink with me and drink as I!
Freely welcome to my cup,
Could'st thou sip and sip it up;
Make the most of life you may;
Life is short and wears away.
—*Wm. T. Oldys, "The Fly."*

Wordsworth, watching a fly as "Between life and death his blood freezes and thaws," is moved in pity to say:

Yet, God is my witness, thou small helpless thing!
Thy life I would gladly sustain
Till summer come up from the south, and with crowds
Of thy brethren a march thou shouldst sound through the clouds,
And back to the forests again!
—*Wordsworth, "A Plague."*

Many poets think little about the insect *per se*, but consider it only as related to their art. They perhaps have an incentive to use insects, similar to that of Izaak Walton, who, with a thoroughness characteristic of anything involved in the furtherance of his piscatorial art, learned the morphology and names of an extraordinary number of insects adapted for fishing. He glibly rattles off lists of names that would tax the resources of a skilled systematist.

There are also divers other kinds of worms, which, for colour and shape, alter even as the ground out of which they are got; as the marsh-worm, the tag-tail, the flag-worm, the dock-worm, the oak-worm, the gilt-tail, the twachel or lob-worm, which of all others is the most excellent bait for a salmon.
—*Izaak Walton, "The Compleat Angler."*

Walton has no scruples whatever in his treatment of insects, dismembering legs or wings with the impersonal attitude of a surgeon. Typical of his indifference to the suffering of the insects used as bait, is the statement: "—in May, June, and July, he (the chub) will bite at any fly, or at cherries,—or at beetles with their legs and wings cut off,—or at any kind of snail,—or at a black bee, that breeds in clay walls." The ruthlessness with which Walton sacrificed his bait, subjecting insects or frogs to an extenuated existence of acute suffering, brought down upon his venerable head the indignation of Byron, who says:

That quaint, old, cruel coxcomb, in his gullet
Should have a hook, and a small trout to pull it.
—*Byron, "Don Juan," Canto XIII.*

Walton, perhaps, should not be judged too harshly for sacrificing everything to his art. While complacently awaiting the bite of the fish, he drifts into a gentle and meditative mood in which he expresses the opinion that anglers are the lords of creation and that insects were especially created for their pleasure. He believes that anglers can not only exploit insects to better advantage but can enjoy them more thoroughly than any one without the pale.

[117] Masefield, "The Daffodil Fields."
[118] Sterne, "Tristram Shandy," Vol. 11, Chap. 12.

And yet I will exercise your promised patience by saying a little of the Caterpillar, or the Palmer-fly or worm, that by them you may guess what a work it were in a discourse but to run over those very many flies, worms, and little living creatures with which the sun and summer adorn and beautify the river-banks and meadows, both for the recreation and contemplation of us Anglers: pleasures which, I think, myself enjoy more than any other man that is not of my profession.

De La Mare, assuming a position exactly opposite to that of Walton, attempts to view the world through the eyes of a fly. With characteristic charm and delicacy, he says:

How large unto the tiny fly
Must little things appear.
A rosebud like a feather bed,
Its prickle, like a spear;

A dewdrop like a looking-glass,
A hair like golden wire;
The smallest grain of mustard-seed
As fierce as coals of fire;

A loaf of bread, a lofty hill;
A wasp, a cruel leopard,
And specks of salt as bright to see
As lambkins to a shepherd.
—*De La Mare, "The Fly."*

The scientist suggests that a more accurate picture of the actual appearance of things to a fly might be given in a mosaic, their many tiny ocelli overcasting all things with the diagrammatic outlines of a mosaic into which pictures are fitted.

The physical suffering of insects is either dismissed as inconsequential or regarded as comparable to that of a human being. "Juggling Jerry" delineates the more general attitude.

I've murdered insects with mock thunder;
Conscience, for that, in men don't quail.
—*Meredith, "Juggling Jerry."*

Pope expresses a very cynical attitude when he says:

Who but must laugh, the master when he sees,
A puny insect shiv'ring at a breeze!
—*Pope, "Moral Essay," IV.*

Shakespeare's broad sympathies include the beetle.

The sense of death is most in apprehension;
And the poor beetle, that we tread upon,
In corporal sufferance finds a pang as great
As when a giant dies.
—*Shakespeare, "Measure for Measure," III: 1.*

With tender compassion Christina Rossetti pleads:

Hurt no living thing:
Ladybird, nor butterfly,
Nor moth with dusty wing,
Nor cricket chirping cheerily,
Nor grasshopper so light of leap,
Nor dancing gnat, nor beetle fat,
Nor harmless worms that creep.
—*Holland, "Butterfly Book."*

Alvar expresses both sympathy and wonder.

You insect on the wall,
Which moves this way and that its hundred limbs,
Were it a toy of mere mechanic craft,
It were an infinitely curious thing!
But it has life, Ordonio! life! enjoyment!
And by the power of its miraculous will
Wields all the complex movements of its frame
Unerringly to pleasurable ends!
—*Coleridge, "Remorse," V: 1.*

Cowper definitely limits his circle of friends to those who share his sympathy for small life.

I would not enter on my list of friends,
(Though graced with polished manners and fine sense
Yet wanting sensibility) the man
Who needlessly sets foot upon a worm.
—*Cowper, "Winter Walk."*

In Richard Le Gallienne's "Ballade-Catalogue of Lovely Things" insects are supremely beautiful.

Imperial sunsets that in crimson blaze
Along the hills, and, fairer still to me,
The fireflies dancing in a netted maze
Woven of twilight and tranquillity;

. . . . .

Prince, not the gold bars of thy treasury,
Not all thy jewelled sceptres, crowns and rings,
Are worth the honeycomb of the wild bee—
So runs my catalogue of lovely things.

Philosophy

From time immemorial the insect has awakened in man the most profound thought of which he is capable.

> Feeble though the insect be,
> Allah speaks through that to thee!
> —*Oehlenschlaeger, "Aladdin's Lamp."*

Gray, observing the insects in spring, said:

> To Contemplation's sober eye
> Such is the race of man:
> —*Gray, "Ode on the Spring."*

The power of the "murmur of the vagrant bee" to start a train of philosophical thought is beautifully expressed in the lines:

> . . . a slender sound! yet hoary Time
> Doth to the Soul exalt it with the chime
> Of all his years;—a company
> Of ages coming, ages gone;
> . . . . .
> But every awful note in unison
> With that faint utterance.
> —*Wordsworth, "Vernal Ode," IV.*

The harmony and unity of all life, the theme perhaps best suited to the philosopher-poet, effectively include insects. As a part of the loveliness of nature are "The cricket's cry and Dante's dream."[119] The conception of all life as one "Vast chain of being"[120] usually embraces insects as being at the other extremity of the scale from man, probably because they are the smallest visible creatures for comparison.

The pagan belief in the existence of a soul in all life, something of the all-pervading, all-permeating power of the divine, is echoed in such lines as

> Yet not the meanest worm,
> That lurks in graves and fattens on the dead,
> Less shares thy eternal breath.
> —*Shelley, "Daemon of the World."*

[119] John H. Wheelock, "Earth."
[120] Pope, "An Essay on Man."

And in—

> . . . a worm whose life may share
> A portion of the unapproachable.
> —*Shelley, "Sonnet to Byron."*

The greatness of a God who can create the largest as well as the smallest things is depicted in the striking contrasts in such quotations as—

> Gives lustre to an insect's wing,
> And wheels his throne upon the rolling worlds.
> —*Cowper, "The Task."*

And—

> Though frail as dust it meet thine eye,
> He form'd this gnat who built the sky.
> —*Montgomery, "Gnat."*

Sharing "eternal breath," the worm worships.

> The spirit of the worm beneath the sod
> In love and worship, blends itself with God.
> —*Shelley, "Epipsychidion."*

> And filled the meanest worm that crawls in dust
> with spirit, thought, and love;
> —*Shelley, "Queen Mab."*

Whether the poet regards Nature as a gentle mother or as a ruthless force, the insect is involved.

> Still do I that most fierce destruction see,—
> The Shark at savage prey,—the hawk at pounce,—
> The gentle Robin, like a Pard or Ounce,
> Ravening a worm,—Away, ye horrid moods!
>
> For nature is one with rapine, harm no preacher can heal;
> The Mayfly is torn by the swallow, the sparrow spear'd by the shrike,
> And the whole little wood where I sit is a world of plunder and prey.
> —*Tennyson, "Maud," IV.*

In a more consoling mood, Emerson, with a belief in the essential goodness of things, says,

> Fear, not, then, thou child infirm,
> There's no god dare wrong a worm.
> —*Emerson, "Compensation."*

Comparing his life, of immeasurably longer duration, to that of the ephemeral

insects, man may acquire an inflated idea of his importance and his grasp of infinity.

So man, the moth, is not afraid, it seems,
To span Omnipotence, and measure might
That knows no measure, by the scanty rule
And standard of his own, that is to-day,
And is not ere to-morrow's sun go down.
—*Cowper, "The Task." VI, 1: 211.*

Man, with his finite limitations, may never pride himself upon comprehending infinity.

In the insect world, the generations come and go before man's eyes. He observes the hurry and flurry of the insects in the seriousness of their life, the cruelties, the hazards of their existence. However, when his thoughts take a more humble turn, he compares his life and its complexity of affairs with eons of time, with innumerable worlds.

Raving politics, never at rest—as this poor
earth's pale history runs,—
What is it all but a trouble of ants in the
gleam of a million million of suns?
—*Tennyson, "Vastness."*

The sun comes forth, and many reptiles spawn;
He sets, and each ephemeral insect then
Is gathered into death without a dawn.
—*Shelley, "Adonais," 39.*

Comparable to Solomon's feeling that "all is vanity" is Hamlet's morbid speculation on the futility of life.

Your worm is your only emperor for diet: we fat all creatures else to fat us, and we fat ourselves for maggots: your fat king and your lean beggar is but variable service,—two dishes, but to one table: that's the end.
—*Shakespeare, "Hamlet," IV, 3.*

The leveling influence of death, bringing all down in equal helplessness to dust, is expressed in the lines—

The great, the base, the coward, and the brave,
All food alike for worms, companions in the
grave.
—*Lansdowne, "On Death."*

The eternal mystery of the universe is suggested by a tiny insect.

So, from the mould,
Scarlet and gold
Many a Bulb will rise,
Hidden away cunningly
From sagacious eyes,
So, from cocoon
Many a Worm
Leap to Highland gay,
Peasants like me—
Peasants like thee,
Gaze perplexedly.
—*Emily Dickinson, LII.*

The lonely splendor of Anatares shines
Through the barred window, and an aphis
crawls
Among the letters and the lines.
Little he guesses what these letters are,
Nor I the meaning of the trembling Word
Written beyond us, star on star.
—*"Meditation," "Best Poems, 1927."*

Wordsworth, oppressed at the baffling mystery, exclaims:

O wretched Human-kind!—Until the mystery
Of all this world is solved, well may we envy
The worm, that, underneath a stone whose
weight
Would crush the lion's paw with mortal anguish,
Doth lodge, and feed, and coil, and sleep, in
safety.
—*Wordsworth, "The Borderers."*

The idea that life is not made up of unmixed blessings is well illustrated by the mixture of gall with honey. "But ay Fortune hath in hire hony galle."[121] Spenser, moodily believing that the evils of love outweigh its compensations, says:

True be it said whatever man it said
That love with gall and honey doth abound:
But if the one be with the other weighed,
For every dram of honey therein found
A pound of gall doth over it redound.
—*Spenser, "Faerie Queene," IV.*

Wherever his search lead him, the eternal mystery which man ever seeks to solve is just as securely hidden beneath the gauzy wings of the most ephemeral insect as in the ocean depths or on the most distant star.

Symbolism

The philosophical ideas suggested to our poets by their contemplation of in-

[121] Chaucer, "Boethius."

sect life are perhaps but the modern expression of those religious ideas with which the insect has inspired man from the most ancient times. A cursory glance through the museums of the world reveals many insects still remaining as the sculptured symbols of religious cults. One naturally conjectures that these ideas, crystallized in stone, lived in the pages of literatures deeply buried under the dust of the ages. The ritual, supposedly elaborate, as befitting a pageantry-loving time, has sunk into oblivion. The blue bee hovering over the head of the ancient Vishnu, the 300 golden bees carved on an altar to the Persian sun-god, and the beetle head of the Egyptian Khepera indicate something of the universality of insects in worship.

Khepera, worshipped as a symbol of self-existent being, is perhaps typical of many gods that were reverenced as provocative of religious ideas.

> The god Khepera has a beetle for his head. The scarabaeus is also called Khepera, by Egyptians. The Scarabaeus or Sacred Beetle symbolised divine, self-created power. The early Egyptians believed it had no female but deposited its generative seed in round pellets of earth which it rolled about by thrusting it backward as it moved, by means of the hind legs 'and this in imitation of the sun, which while it moves from West to East turns the heaven in the opposite way.' From this mysterious ball the beetle comes forth full of life after twenty-eight days of incubation by the moon. It was believed that the beetle was born anew from the egg which it alone had created, and thus it symbolised for the Egyptians self-existent being. It was so highly reverenced that the wings on the winged glove or sun disk—the sacred symbol of the deity—have been thought by some to represent the scarabaeus instead of the falcon.
>
> —*Werner, "Myths and Legends of Chian."*

A certain Egyptian divinity was supposed to dwell in Aphis, a bull, which could be identified by very unusual markings

> . . . a square white spot on the forehead, the figure of an eagle on the back, a white crescent on the right side, and the mark of a beetle under the tongue. When the bull died, the god was expected to take up its habitation in another bull with similar marks of identification. Strangely enough, the priests invariably succeeded in finding 'an animal with their extraordinary marks, and the happy event was immediately celebrated throughout Egypt.'
>
> —*White, "The Student's Mythology."*

The gods of insects were not always worshipped in a spirit of loving reverence, but sometimes in a spirit of awe and with propitiatory motives. The Egyptians doubtless had no love for Beelzebub, the god of the flies, but knelt to him with a prayer that he render flies less obnoxious. Unless they accorded this deity their worship, they feared that he would convert the flies, always a potential menace, into a loathsome reality. Some scholars advance the theory that they worshipped Khepera, not because of its religious symbolism of self-existent being, but because of the fact that the scarab destroyed the worms of the Nile.

The insect enters largely into universal worship, not always as a deity, but more often because of its association with things divine. The bee was engraved upon ancient tombs as a symbol of immortality. The Greeks, with a typical appreciation of the harmony of body and soul, carved, along the dark walls of the catacombs, the butterfly as the "soul's fair emblem,"[122] emblematic also of the Christian's conception of Easter.

Though rejecting all "heathen" gods, the Israelites retained the heathen belief that wisdom and inspiration came as a result of feeding upon honey. Isaiah advises:

> "Butter and honey shall he eat, that he may know to refuse the evil, and choose the good."
>
> —*Isaiah, 7: 15.*

Jonathan, contrary to his father's command, "put forth the end of the rod that was in his hand, and dipped it in

[122] Coleridge, "Psyche."

an honeycomb, and put his hand to his mouth; and his eyes were enlightened.[123]

In his "Hymn to Mercury" Shelley says that the three fates,

> . . . Whilst they search out dooms,
> They sit apart and feed on honeycombs.
>
> They, having eaten the fresh honey, grow
> Drunk with divine enthusiasm, and utter
> With earnest willingness the truth they know;
> But if deprived of that sweet food, they mutter
> All plausible delusions;

Japan, while not worshipping them, reverently relegates fireflies to the realm of the blest as the ghosts of slain warriors, who by virtue of sacrificing their lives for their country win eternal bliss.

Many insects are symbolical, in a more restricted and provincial way, of some evil augmented locally by their superabundance. In New Jersey the mosquito, actually the most frequent cause of the loss of temper of the good citizens of that state, becomes symbolical of all the annoyances and petty tribulations that fall to the lot of man.

The cicada, appealing to some as annoyingly loquacious and to others as continuously melodious, has become the symbol of both garrulity and Apollo.

The bee has long been the symbol of prosperity. The promise of a land of plenty, a "land that floweth with milk and honey," helped the children of Israel to forget the flesh pots of Egypt and cheered them during long years of wandering in the wilderness. When hardships seemed well-nigh unbearable and they were on the verge of revolt, the words of the prophets reminding them of their ultimate reward, of the "land flowing with milk and honey" fell as a soothing balm on their troubled spirits.

Insects have been chosen as political as well as religious symbols. The dragon-fly in Japan is the emblem of victory and naturally finds a place in the literature of the country, especially that commemorating past successes and arousing patriotic fervor for fresh encounters.

As his emblem of sovereignty, Napoleon chose the bee, which he wore carved on his signet ring, the official seal of the realm.

With a penchant for forecasting events, similar to that of an astrologer reading a horoscope, Mizaldus interprets the worm in the oak-apple. "If you take an oak-apple from an oak tree, and open the same, and shall find a little worm there, which if it doth flye away, it signifieth wars; if it creeps, it betokens scarceness of corn; if it run about, then it foreshows the plague." Elsewhere we find: "The fly in the oak-apple is explained as denoting war; the spider, pestilence; the small worm, plenty."

Amber

Insects formerly passed unnoted become through the influence of the poet objects of beauty and value. In the words of Browning,

> . . . we're made so that we love
> First when we see them painted, things we have passed
> Perhaps a hundred times nor cared to see.
> —*Browning, "Fra Lippo Lippi."*

The tiny gnat or the infinitestimal aphis, embalmed in the amber bead of poetic thought, becomes even more precious to mankind than those beads that fell from the tree of Phaeton to envelop the tiny ants that wandered beneath her shade. Equaling if not surpassing all other gems in the poet's box of jewels are his amber beads preserving in enduring beauty and freshness not only the most unpretentious little insect but the most colorful butterfly that wanders into his garden.

The rich, sweet nectar from his flowers of thought has crystallized into lus-

[123] 1 Samuel, 14: 27.

trous amber, a "more than royal tomb," enhancing the beauty of the encased insect. But if the insect receives an added beauty from its lustrous tomb, it in return gives form and color to an empty tomb. The poet's amber bead may be likened to the fly's ivory tomb.

A golden Flie one shew'd to me,
Clos'd in a Box of Yvorie:
Where both seem'd proud; the Flie to have
His buriall in an yvory grave:
The yvorie tooke State to hold
A Corps as bright as burnisht gold.
One Fate had both; both equall Grace;
The Buried, and the Burying-place.
Nor Virgil's Gnat, to whom the Spring
All Flowers sent to 'is burying;
Nor Marshall's Bee, which in a Bead
Of Amber quick was buried;
Nor that fine Worme that do's interre
Her selfe i' th' silken Sepulchre;
Nor my rare Phil, that lately was
With Lillies Tomb'd up in a Glasse;
More honour had, than this same Flie;
Dead, and closed up in Yvorie.

—*Herrick, "Upon a Flie."*

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MATERIAL CULTURE AND THE RACIAL MATRIX

By Dr. WALTER HOUGH

HEAD CURATOR OF ANTHROPOLOGY, U. S. NATIONAL MUSEUM

MEN who handle large numbers of museum specimens from races in all parts of the world come to sense subtle differences and resemblances in the material. The specimens present certain criteria or stigmata left by the hands of the workman by which they usually may be at once classed as Asiatic, African, Australian, American, and the like. This critical faculty is constantly exercised on almost all the complex impedimenta of modern life by experts who do not require the legend "Made in Germany," "Made in Japan," as a guide.

The criteria mentioned, representing observed data, may be referable to racial traits and may cover whole continental areas.

It seems to be feasible, then, to present a theory of a racial matrix producing recognizable characteristics of art products. If so, the evidence of distinctive traits easily observable points to means of classifying the phenomena of art expression among different races. By art expression is meant the unconsciously produced residuum taken to be the impress of race. The word art also is used to comprise any product of handicraft however common as well as other phases of arts and art culminating in the esthetic.

Such traits may be either strongly unmistakable or softened out by the constant changes in racial history exactly like the phenomena encountered in racial admixtures considered in physical anthropology by which pure races have been eliminated. It remains to be seen whether something deeper and more ingrained does not survive what seem to be major changes mentioned above.

A racial matrix producing recognizable characteristics of art expressions may seem difficult of proof, but traits are observable, however, indicating an indefinite something inherent in these expressions. Doubtless this something is the possession of every individual, unconsciously delivered as part of self-expression, and for lack of better classification may be termed psychological, or even going back to certain as yet undiscovered fundamentals in biology that act as reagents of stimuli in the production and determining of forms.

Resemblances in arts and industries have been explained by the alleged law of stimulus, the idea being that the mind will always respond to the need, for instance, of a tool by creating it through a series of obscure interactions. Some such rule it may be conceded would perhaps obtain for the simple basic tools which result from fundamental impulses, but it is more than doubtful that the rule would apply to complex adaptations. A cocoanut stripped of its husk by manual effort may be broken by throwing it against a harder object, by bashing two nuts together, or by means of a hand stone, which by this use is immediately classed as a hammer—in this phase a tool closest to instinctive actions the world over. The hammer develops in its lower stages by a succession of such actions growing more complex till it reaches beyond the sphere of

primary actions. Thus a hammer or other tools may be independently invented and indistinguishable from other hammers and tools. But at each step in advance the hammer takes on individuality, has received something from its maker which will terminate in giving the tool the impress of racial art.

The broad general subject presented for discussion is whether there is distinctive racial art. The discussion may bring out the philosophy of style in regard to the products of material culture.

Another phase of the question bearing on the theory of a racial matrix has been recently raised by Dr. C. B. Davenport, of the Carnegie Institution of Washington. The existence of certain mental racial traits is maintained by Dr. Davenport, and it is his belief that these are hereditary, descending from generation to generation with such factors as the color of the skin. By means of exact experimental work in the line of tests to bring out mental differences Dr. Davenport has been led to advance his thesis.

From the nature of the case there is doubt expressed as to the validity of tests applied by one man to another, hence these tests meet with little acceptance in determining racial differences in mental reactions. The application of tests giving obviously valuable results within races is conceded, but the tests applied by the man of one race to that of another are viewed critically both as to tests and results. Nevertheless, Dr. Davenport's conclusions are supported by the visual observation method on objects of material culture advanced in this paper. In one case the brain product or psychology is fluid, and in the other it is fixed.

Owing to the unequal spread of racial arts, peculiarities are stronger and may be better observed in certain lines of handiwork such as pottery, lacquer and other products that require a personal touch, and especially in drawings, paintings and modeling. In this sense racial art evidences become more vivid with the progress of culture, though it is contended that it is evident in every product turned out by man.

Incidentally it may be more than probable that the origins of phases of arts were the product of individuals endowed with unusual capabilities. This would explain the sudden appearance of arts without discoverable antecedents. Such phenomena, however, are more evident in somewhat advanced stages and flower in the highest civilization.

There is also little reason to believe that human art has a common genesis. On the contrary the phyla of art are as divergent as the phyla of the animal kingdom.

The vitality of racial art characteristics may be assumed from the facts presented. Art may be termed protean, yet in the changes recognizable in centers and nooks and corners over vast geographical areas there can be discerned a unity in fundamental pattern. It is manifest that developments will take place in certain lines. In the fine arts, major and minor, here portraiture will flourish and there sculpture, decoration will be modified by materials, as textiles or prepared or natural surfaces, by pigments and many other materials and processes leading to a great variety, local or wide-spread, yet the impress will be racial throughout the whole complex.

In the application of the theory of racial art, supposing that it has validity, certain conclusions are reached. If there is a recognized Asiatic art impress, for instance, may we not apply it to the test of the origin of the art of the Western Hemisphere, thus supplying an additional proof of the peopling of America from the old continent? Obviously the generalization that the American aborigines could only originate from Asiatic

stems is the statement which appears to many as an incontrovertible fact of physical anthropology.

Whether racial art would survive the vast distribution of population in the environments of the New World and come true to race is subject to discussion. It also requires a discrimination of extraordinary keenness to see in the complex manifestations of the art instinct among the tribes from the Eskimo to the Fuegians. Possibly in less advanced tribes small traces would be apparent, while in the civilized tribes the fruition of their art brings it out strongly enough to suggest direct Asiatic contact. In such cases as the latter the suggestion comes forward that the requirements of a suitable environment have been met for racial art to come true to form. In this respect we have Maya art in the advance of these people coming to attain a marked Asiatic phase also observed in the highly civilized Asiatic groups. This would counteract the far-fetched assumption of direct Asiatic contact in Central America that has proven misleading to many students.

In this line it is not possible to predict what has entered from various sources into the development of the art of a given race or what profound changes may take place when trammels are unloosed in high civilization, as for instance, in Europe. America, however, shows in its civilizations an uninterrupted development that has worked out in established lines. Thus Middle American art reached a more distinctly Asiatic character than Peruvian art, yet both have the same racial impress.

In reference to the groups entering America from the Asiatic continent it may be surmised that the arrivals had something more than the mere food, shelter and minor arts complex. They had this trait under discussion, and its development in America with all its shades, which now admit of the classification into strongly marked areas of design, remained Asiatic.

It has long been recognized that what is perhaps loosely called national art affords interesting comparisons. An outstanding example is the variety in the pictures of Christ. These pictures are necessarily imaginative, but, being a wide-spread subject for painters and sculptors, are excellent material for a study of the individuality expressed in national and beyond this in racial terms.

Familiar examples are portraits by Italian, Spanish, French, Flemish, Dutch, English and German artists, not affected by knowledge of racial characteristics and all having the European impress.

An Indian potter of Tonalon, Mexico, was commissioned to make a miniature bust of President Grover Cleveland from a cut in *Harper's Weekly*. This bust, now in the United States National Museum, is a good example of the meticulous work of the Guadalajara school of potter artists, whose remarkable creations in fragile material should be world famed. The bust is recognizable at once as of Cleveland, but in every lineament a Mexican simulacrum of the president.

A Japanese employed by the Commercial Museum of Philadelphia as a sculptor produced figures of American Indians which were startling renditions of the Indian as a Japanese. It might be said that the sculptor saw the Indian in that way, but in reality underlying his concept was subconscious predilection forcing his product into a racial mould.

Another example that may be given of the fixity of racial art is the effect on art forms of calibrated units, as beads and textile stitches. With these fixed units a uniformity of product would seem to be inevitable. Yet even here enter racial factors. Thus a piece of Bagobo beadwork would be instantly detected among American Indian specimens and pro-

claimed foreign though both classes show Asiatic traits rather than African or other regional decoration.

An instance of the breaking away from the static art conditions which envelop the artist is noted among the aborigines. A Western Eskimo, as stated by Dr. W. H. Dall, the Alaskan explorer, took up of his own accord the carving of realistic figurines which he did with remarkable skill and fidelity, shown in specimens of his work in the U. S. National Museum. On account of his departure from Eskimo standards of conventional art this man was regarded by the tribe as an iconoclast and was punished with suspicion and ridicule. It is evident that there may be a return to nature for types not only by individual artists and craftsmen, but by larger groups of mankind, but these manifestations of revolt, however, are soon lost in the compelling force which determines racial fixity in art. In fact they never can break entirely away from these inherent tendencies.

Within racial art may be recognized concentrations of varying intensity that may be termed national, embracing a group of people within well-defined boundaries or covering an indefinite geographical area. Under this class also comes tribal art, in which a single group may show a distinctive style cultivated in isolation. This occurs rarely, the usual state being a group of tribes in an area showing at the boundary marginal diffusion tendencies in the art. Areal or environmental art is the obvious unit selected by the investigator for description and comparison.

In the last group are noticed local and period art, the former furnishing the type development generally used as the index of the whole areal phase. Period art refers to the stages of progress or decay which admit of characterization as schools. Within these schools arise climaxes of achievement standing out as finalities in certain lines. This brings art down to the expression of individuals who produce works of the highest merit and who furnish leadership.

In so complex a problem many indeterminate elements exist, that is, conditions presenting faint criteria scarcely useful in detecting racial art. Thus we may have pronounced styles, lukewarm or even neutral styles, depending upon primary impulse, opportunities and education.

The object of education in art is to acquire skill derived as a result of the training of the hand and mind and an acquaintance with the grammar of design. This represents philosophically the bodying forth of a symbolic world of art based like the physical world of science on measurements, but with a different aim termed beauty. Gradually by the use of the components of the arts of design the producer finally reaches an expression which is his style, perhaps becoming an intensely individual characteristic recognizable as belonging to his work.

In the attainment of individual style there may be several periods in each of which the style for the time being seems fixed, but for want of better expression the artist is seen in all these.

It is conceived that the process by which individual characteristics become fixed may in some way be connected with the development of racial characteristics of art. It can not be said, however, that racial genius is produced in the summary way used in the teaching of art. There are in both cases large areas of unknown factors lying beyond present knowledge that perhaps could explain why the arrangement of forms, spaces, plus something in the human makeup, produce beauty.

CHARTING THE SEA AND THE AIR

By Rear Admiral W. R. GHERARDI, U.S.N.
HYDROGRAPHER OF THE NAVY

CHARTS are the first requisite for navigation—whether it be the sea or the air. Ships without charts would be as much endangered as ships without rudders. This also holds true for aircraft engaged in long coastal or transoceanic flights. Charts are a vital necessity in the navigational equipment of the ship and of the airplane. They are the other brains, the silent comrade, needed by the pilot, may he be voyaging by air or by water. They are his second vision—his direction finder—his guide and counselor.

It is the work of the Hydrographic Office of the United States Navy to collect, digest, and to issue timely information to the seamen and airmen so as to afford them the greatest possible navigational safety. To furnish them the benefits of new discoveries in science pertaining to land and sea has been the incentive of the Naval Hydrographic Office since its founding in 1830.

The work of the Hydrographic Office involves taking into account scientific matters relating to the ocean and the air and their navigation. But before all else, charts must be accurate—reliable without a chance for doubt on the part of their user.

Great changes have been recorded since Leif Ericson sailed southerly seas only because there was less ice to check the progress or endanger the safety of his galley, and Columbus knew he had come to a country unknown only by the strangeness of the birds that were his first welcoming hosts in a new land. Since then science with its charts for directions, distances, dangers and depths has made travel by sea safe instead of haphazard.

Cartography, or chart making, had its beginning in early days, when man first began to venture on the water. These early charts consisted of the merest details and were confined to the shores bordering the Mediterranean Sea. We know that the maps of the Egyptians drawn on papyrus date from about 1300 B. C. The development of the chart may be traced through the ensuing centuries, changing with new discoveries and new methods of printing, engraving and lithography. The maps of the astronomer, Ptolemy, taken from the teachings of Marinus of Tyre, were in use for about fifteen hundred years, until the discoveries of Columbus dispelled the popular belief that the world was flat. During this period they crudely served their purpose and the maritime world of those days. In the sixteenth century a Flemish mathematician gave to the world the Mercator Chart, so called after his Latin name. The principles involved in this chart are those embodied in the charts mostly used by seamen to this day.

As civilization progressed, the mariner's travels took him farther from those known shores. He ventured from the Mediterranean Sea to the Atlantic, touched the north on the shores of the British Isles, groped eastward along the Red Sea and finally reached the southeast by the Indian Ocean. After the adoption of the mariner's compass and the discovery of America by Columbus, overseas exploration received a great impetus. The search for gold, for new lands, for conquest or development were incentives for overseas explorations. These adventurers of the late middle ages sailed a trackless ocean, and re-

turned bringing strange tales and crude drawings of the seas and lands they found. It was that age of great imagination which stirred and started discoveries in science of the sea.

The evolution of the chart paralleled new discoveries in science.

To-day, the more a country develops its industries, the more it becomes dependent upon other nations of the world and, hence, the greater the development of its foreign trade.

To safeguard this shipping maritime nations have been active in their hydrographic surveys during the past century. It is only since the latter part of the past century that nautical charts of the different nations have become more or less standardized. As a result, the modern accurate chart of to-day is of comparatively recent origin. To further this standardization, the International Hydrographic Bureau at Monaco was established in 1919 by the maritime nations.

In the United States, the Naval Hydrographic Office is authorized by law to issue charts to the vessels of the United States Navy and Merchant Marine and is given the task of making original surveys of foreign waters and producing charts of the high seas, and of foreign waters. The task of charting the coasts of the United States and territorial waters is performed by the United States Coast and Geodetic Survey. America has done its share in the scientific work of charting the seas. The names of Wilkes and Maury, both of the United States Navy, are indelibly stamped on the pages of the hydrographic development of the world.

During the course of years, since the establishment of the Hydrographic Office, naval vessels have made surveys in Korea, China, Mexico, Central America, West Indies, Brazil, Uruguay, the North and South Atlantic, North and South Pacific, Indian Ocean and in the Great Lakes. From these expeditions large additions have been made to a broader knowledge of our globe.

In constructing a chart it is essential that it should be correct in its geographic position. The accurate determination of the latitude and longitude of the chart is of the utmost importance to the navigator who must be able to fix his exact position from it. Successive telegraphic longitude expeditions have been sent out at intervals since 1874 by the Hydrographic Office. Now the use of radio greatly simplifies the problem of fixing longitudes.

Each maritime nation is interested in the charting of its own coastal waters and those of its dependencies. Many of them have efficient and well-organized hydrographic offices as part of their naval establishments which carry out their own surveys and publish charts for the use of the seamen. This hydrographic information is exchanged between nations, and foreign government charts are utilized, and their information is incorporated in various charts and publications produced by the Naval Hydrographic Office. There are still great areas which are either unsurveyed or not sufficiently surveyed for modern requirements of our large deep draft ships. And again, well-surveyed coasts and harbors are constantly undergoing natural and artificial changes which must be corrected on the charts if safety of navigation is to be secured.

The Hydrographic Office is still carrying on surveys of the high seas and foreign coasts. At the present time there are three such expeditions surveying the coast of foreign territories whose governments are not equipped to do their own surveys. The U. S. S. *Nokomis* is surveying in Cuban waters, the *Hannibal* in Venezuela, and the *Fulton* is to continue a survey in the

Gulf of Panama, where the present charts of these localities, based on very old surveys, are reputed to be many miles out. Aircraft are used to assist these specially equipped vessels in their work by photographing the terrain preliminary to the ground work. Hydrographic surveying has adopted the latest methods and instruments which have become available to surveys ashore, afloat and in the air.

All charts are corrected to date of publication and are kept up to date until issued. They may be classified as general, coastal and harbor charts, and are supplemented by "Sailing Directions," "Notice to Mariners," giving corrections or added information, and other publications.

An activity of increasing importance for the Hydrographic Office is that of safeguarding aircraft in transoceanic or coastal flights.

To take care of this need, sets of air charts for the coasts of the United States, Mexico, Central America and the West Indies are now complete and being issued. There is a comprehensive charting program underway which embraces the entire coast of South America. A series of handbooks, air pilots, comparable to sailing directions of nautical charts, are now in the course of preparation.

Progress has gone on to-day, so that charts for navigation of the air are as important as those for navigation of the sea. The aviation chart has a different appearance from the nautical chart in that it is especially constructed to indicate prominently those features visible from the air and by which the aircraft pilot determines his position. They must also be of a size to be used in the restricted space of an airplane cockpit.

In our studies of the upper air it seems reasonable to predict that the aviator will eventually have charts that will point out to him air currents of the upper air as did Maury's Pilot Charts show the winds on the ocean's surface to the navigators of sailing vessels. Such well-known aviators as Lindbergh and Hawkes in their non-stop transcontinental flights flew at times at high altitudes to take advantage of the favorable effect of upper air currents when blowing in the direction they were heading.

The Hydrographic Office is now publishing monthly a Pilot Chart of the Upper Air for the North Atlantic and one for the North Pacific.

As was the case with nautical charts, when air commerce creates the demand, it is safe to predict these upper air charts will become of such importance to the aviator in long flights that they will be issued to cover all parts of the globe.

The United States Exploring Expedition of 1838 to 1842, headed by Lieutenant Wilkes, was the first scientific expedition to leave the shores of the United States fitted out and provided for by an Act of Congress. It was the outstanding survey of its day and was created as a result of popular sentiment that the United States should take a larger part in the scientific work for the advancement of navigation and commerce. From those days to these, the Hydrographic Office of the Navy has progressed and kept pace with the needs of our complex civilization with regard to navigation and hydrography of the sea and of air. Great opportunities lie before it, and if the past be a test by which the future can be gauged, these opportunities will be realized.

THE THIRST OF PLANTS[1]

By Dr. D. T. MacDOUGAL
CARNEGIE INSTITUTION OF WASHINGTON, DESERT LABORATORY, TUCSON, ARIZONA

THE fundamental thirst of living matter, especially in plants, as expressed by wilting of crops, failure of forage and direct needs of domestic animals and of man himself, has incited inter-tribal conflicts, has laid the foundation of wars between peoples, and has been the cause of racial migrations affecting civilization in the profoundest manner. The water problems of a city of over a million people in one state have recently led to the expropriation and assignment of the water of one of our largest rivers, and a controversial discussion by the people of seven states occupying an area of half a million square miles. It is highly probable that among the earliest agreements between family or tribal groups were those as to the shared use of limited supplies of water; agreements that may well have constituted the beginnings of an important section of human laws. Although living substance may contain 99 per cent. or more of water, yet plants are forever thirsty, and when active, continually take in and lose water.

The growing substance in tender root-tips, in swelling buds, in the fragile wood-forming cambium layer of tree trunks, and in enlarging fruits, may have as much as a hundred or a hundred-and-fifty parts of water to one of solid matter, but as the liquid is being lost all the time a continuous new supply is necessary. An understanding of this condition is possible only on the basis of a comprehension of the ultimate structure of the living substance or protoplasm, which is far beyond the resolving power of the microscope.

The matter may be illustrated by filling a drinking glass loosely with excelsior or wood-fiber packing, then pouring in water until it rises up to the brim. So water is placed among the ultimate strands or particles of protoplasm, which—unlike the wood fibers—adhere by their poles like fragments of magnetized iron. These molecular clumps, or strands, unlike the wood fibers, also bind the water in much the same manner as they hold to each other, so that it does not run out freely: when the water is forced out by pressure the fine meshwork or grouping of the molecules is broken up and the protoplasm is injured or destroyed.

If instead of pressure the water should be slowly evaporated from the surface of the mass of living matter, the fibers would be brought closer together with an accompanying concentration of the sap which slows down the activities which constitute life. This is the universal effect of thirst.

Crop plants and forest and fruit trees obtain their water-supply from layers of soil of varying depths. The roots of some species form great webbed sheets of wide extent just underneath the surface. Others send rootlets deep into the sub-stream. The first habit is especially prevalent in places where the rainfall is used as soon as it soaks into the ground. Deeply penetrating roots are suitable for tapping ground water. The amounts of water these root-systems must take up is illustrated by the citation of the fact that a common sunflower with a spread of leaves of a total area of about 11 square yards will evaporate about a quart of water as vapor from its leaves in a day, and 75 quarts in the course of its development. A corn plant takes up about 16 quarts of water during its life-

[1] A radio talk presented under the auspices of the National Research Council.

time; a hemp plant twice as much. An acre of cabbage plants needs over two million quarts of water in a season. Two hundred beech trees on an acre require nearly double this amount. One of these trees loses about 80 quarts of water as vapor daily from its leaves. An acre of oat plants throws a million quarts of water as vapor into the air while maturing.

Irrigation practice must put enough water into the soil to replace losses from leaves, and losses from the surface of the soil as well as the amount actually used or bound in the tissues. The farmer knows that over 600 pounds of water must be put into the soil to produce one pound of dry alfalfa, while the forester estimates that half a ton is necessary to make a pound of wood.

The plant is not simply a mass of jelly which soaks up water from below and loses it from upper exposed surfaces. It is a complicated living mechanism, a converter of the energy of sunlight into power. Some of this energy is used in making chemical compounds: but 98 per cent. of the energy absorbed by leaves and other green expanses of the plant is used in evaporating water from the surfaces of the cells. The work of lifting water from the rootlets deep in the soil to the crown of tall trees, to heights as great as 400 feet, is done by power generated in this manner.

This movement of liquid in the ascent of sap is as important as is the circulation of our blood. The movement in plants is not a circulation, however. Watery solutions rise from the roots to the leaves where most of the liquid goes into the air as water vapor. Only a small fraction of the water which moves rapidly upwardly in the woody conduits of stems is bound or held in chemical combinations in the cells.

The plant as a sun-driven factory holds its green absorbing surfaces so that the rays of light will be advantageously received and their energy effectively absorbed. Part of this mechanical function is accomplished by the concentration of stiff, rigid stems and branches of woody material. The firmness of the leaves and of all tender and fast growing parts is brought about, however, by another employment of water. In explanation of which it may be said that the living matter of plants is in the form of small units, protoplasts or cells, the elastic walls of which are capable of being stretched to as much as half their length like the walls of a toy balloon.

The living balloons have a layer of jelly on the insides of the cellulose walls. Water instead of air is pulled through the walls and lining layers of jelly with a force which may exert a pressure of a ton to a square inch. A stem, a leaf or a flower, the cells of which are distended by such pressures, will have great rigidity and firmness.

Production of sugars and other organic substances in green leaves depends directly on the extent of green surfaces exposed to light. Over-extension of the surfaces will be followed by undue loss of water which weakens this pressure and results in wilting. A maple, oak or pine tree may form leaves with a total area from a half to two acres. The loss of water from such extended surfaces is very large and hundreds of kinds of structural devices have been perfected by plants which regulate and control evaporation from leaves. The covering layer or epidermis may be dense, waxy or water-proofed to prevent useless loss of water. Then there are present numerous openings or stomata controlled by guard cells which act like valves. When these are open evaporation of water takes place as if the waterproof epidermis were removed: closed, the loss is negligible.

Water has been the major factor affecting the evolutionary development of all vegetation. No more striking illustration of the effects of water require-

ments on the form of plants can be cited than is afforded by the twelve hundred kinds of cacti inhabiting North and South America. Such plants absorb great quantities of water in a rainy season which can be used in dry times. A tree cactus may hold many hundreds of gallons of surplus water. Many plants in the arid regions of Arizona and Sonora have now a water supply laid in which would keep them alive until 1933 or 1934. A vine of the squash family, native to Sonora, stores water in an expanded base in such quantity that individuals have been known to live for fifteen years on their reserves.

The skilful use of the water supply, based upon a comprehension of the part it plays in living matter, is fundamental to intelligent agriculture and its dependent industries. Descriptions of the known features of use and storage of water by plants would fill many volumes. Enough has been said, however, to make it evident that life is where water flows; and that living matter is largely made up of water which is continually being lost, so that plants are forever thirsty.

THE EXTIRPATION OF ONE BUTTERFLY BY ANOTHER

By AUSTIN H. CLARK
U. S. NATIONAL MUSEUM

How is it possible for one kind of butterfly to extirpate a closely related kind? There is no question that this actually happens, for since the introduction of the European cabbage butterfly (*Pieris rapæ*) into North America we have seen the native gray-veined white (*Pieris napi oleracea*) entirely disappear from a large area formerly inhabited by it, while the checkered white (*Pieris protodice*) also has greatly decreased in numbers.

Observations recently made in the vicinity of Washington suggest a possible explanation of this interesting problem.

During the past four years the orange clover butterfly (*Colias eurytheme*), an intruder from the West, has enormously increased in numbers in the District of Columbia and the immediately adjacent region, and within the past two years the numbers of the native local species, the common yellow clover butterfly (*Colias philodice*), have not only relatively but actually decreased. The native yellow insect is becoming scarcer as the orange western form becomes more common.

The orange species is a stronger and much more active butterfly than the native yellow species, and wherever they are found together the differences between them are at once obvious and striking. Furthermore, when they are found together the males of the orange butterfly frequently are seen to annoy both sexes of the weaker yellow species.

Perhaps the most familiar of the butterflies that gather in little companies on mud in the late summer are the males of the yellow clover. These little companies of males represent individuals temporarily or permanently exiled from the fields through persecution at the time, immediately after the emergence from the pupa, when their chief interest in life is quiet and uninterrupted feeding. In other words, they are the victims of overcrowding in the home territory.

The orange males are never seen on mud—only in the fields. This species seems to be quite insensitive to over-

crowding. Indeed, in portions of the West it becomes a more or less serious pest from time to time, and in some sections its caterpillars—known locally as "alfalfa worms"—do really serious damage.

From the known habits of these two clover butterflies we would infer that wherever they occurred together the yellow species would be affected by the males of the more active and stronger orange species more than it would by its own males, whereas the orange species would not in any way be affected by the yellow.

Thus overcrowding in the case of the yellow species would occur in proportion to the numbers of the males of the two species combined instead of merely in proportion to the numbers of the males of the yellow form alone. So with the increase in the numbers of the orange species the yellow would gradually decrease in numbers through the driving out from the breeding areas of the yellow males, and through the decrease in the number of successful matings as a result of the constant annoyance of both sexes.

This seems to be what is actually taking place. The strong and active orange species (*Colias eurytheme*) is causing a progressive diminution in the numbers of the weaker and less active yellow species (*Colias philodice*). It will be interesting to see whether the yellow species will be able to maintain itself in the face of the continued competition of the orange, or whether it will be reduced to insignificant numbers or even perhaps die out.

Years ago the checkered white (*Pieris protodice*) was very common in the District of Columbia and occasionally was more or less destructive to cultivated cabbages. It is a weaker and less active butterfly than the European white (*Pieris rapæ*) and is subject to persecution by it. The relations between the checkered and the European white are almost identical with those between the yellow and the orange clover butterflies. It is quite probable that the almost complete disappearance of the checkered white has been due mainly to constant persecution of both sexes by the males of its more active and more powerful competitor.

The disappearance of the gray-veined white (*Pieris napi oleracea*)—also a weaker and less active butterfly than the European white—from most of the territory formerly inhabited by it in the eastern United States may have been due to the same cause.

Incompatibility without direct competition seems to be causing the displacement of the yellow clover butterfly by the orange in the vicinity of Washington. The relations between these two very similar butterflies should be watched carefully from year to year. From observations on these insects we may learn something of much interest in the interrelationships of animal forms.

PHOTOMICROGRAPHY WITH ULTRA-VIOLET LIGHT

By A. P. H. TRIVELLI

THE EASTMAN KODAK COMPANY, ROCHESTER, N. Y.

In the second half of the nineteenth century Ernst Abbe laid the foundations for a new optical industry at Jena, Germany, which, under the guidance of his great scientific and executive ability, developed into an outstanding center of theoretical and practical optics. Abbe's famous work on the modern microscope is among the successful attempts to develop the knowledge of optics, and he determined the theoretical conditions required to reach the highest resolution with microscopic enlargements. Resolution, that is, the visibility of details, is determined by two factors: (1) it is proportional to the numerical aperture of the optical system, and (2) it is reversed in proportion to the wave-length of light used.

The aperture of the optical system does not in itself furnish a measure of the resolving power, but from Abbe's theory of the formation of microscopic images it follows that the sine of half the aperture angle supplies such a measure. For the ordinary optical systems the highest numerical aperture obtainable is nearly 1. In a microscope the object to be enlarged is placed on the stage between the condenser and the objective. The numerical aperture of the system can be increased by putting the object between condenser and objective in a homogeneous medium having a refractive index higher than that of air, that is, immersion oil. In such a system the numerical aperture is determined by the sine of half the aperture multiplied by the refractive index of the immersion liquid. With the introduction of the immersion method Abbe, using cedar oil, was able to increase the numerical aperture to 1.4. Czapski, using an immersion liquid of still higher refractive index, was able to increase the numerical aperture to 1.6. Objectives with such high numerical apertures, however, have practical disadvantages. The numerical aperture is also a measure of the power of penetration or depth of focus, which decreases with increasing numerical aperture. This makes it very difficult to get satisfactory results with Czapski's objective.

For most practical purposes a numerical aperture of 1.3 is sufficient and only in extreme cases are optical systems with a numerical aperture of 1.4 employed. About thirty years ago A. Köhler, of the scientific staff of the Zeiss works in Jena, increased the resolution of the microscope by introducing the use of ultra-violet radiation in combination with photography. The equipment was made available by the firm of Carl Zeiss, and while at first very little was done with the apparatus, in the able hands of F. F. Lucas, of the Bell Telephone Laboratories, it has proved to be of value for biological and histological investigations. Two objections were mainly responsible for the limited application of Köhler's method at first: the very high price of the apparatus, and difficulties in focusing. At the present time we have a number of institutions in the United States which can afford the expense of the Köhler outfit, and since laboratories are realizing more and more that for micrographic work of the first order skilled people with a scientific education are needed, Köhler's ultra-

violet micrography opens greater possibilities of application.

The use of ultra-violet radiation in micrography is limited by its absorption. In general, radiations of wave-length shorter than 250 mμ (1 mμ, or millimicron, = one twenty-five millionth of an inch) are strongly absorbed by many objects so that micrography in this region becomes limited in its application. Ultra-violet micrography of wide usefulness must limit itself to the region between 400 and 250 mμ wave-length of radiation. Ordinary optical glass of every kind absorbs all ultra-violet wave-lengths shorter than about 300 mμ. This makes the usefulness of the region between 300 and 250 mμ wave-length possible only through the use of an optical medium, such as quartz, which transmits this radiation.

Von Rohr had already suggested the use of so-called monochromats—objectives which are corrected for only one wave-length of light. The characteristic feature of these objectives is that the rays are brought to a focus in a very perfect manner with respect to a specified wave-length, the combination being accordingly entirely devoid of chromatic correction. Furthermore, the system is made up of uncemented lenses, all of which may be composed of the same material. These objectives were used by Köhler in photomicrography with ultra-violet light. For the rest, success depends upon a monochromatic light source of high intensity. As the result of a systematic search Köhler found two useful light sources: the magnesium spark giving a line of 280 mμ wave-length, and the cadmium spark giving a line of 275 mμ wave-length, this line being 50 per cent. stronger than the other. To obtain the highest possible resolution an immersion liquid other than cedar oil had to be found. Cedar oil is too opaque for the ultra-violet. Glycerin was suitable, but its index of refraction necessitated placing the maximum numerical aperture of the quartz system at 1.25.

Oblique illumination doubles the resolving power. The extreme resolution of Köhler's photomicrographic outfit is 0.11 micron (1 micron = one twenty-five thousandth of an inch), which means that two lines separated from each other more than 0.11 micron will be visible on the negative and two lines separated from each other less than 0.11 micron will be reproduced as one single line. In ordinary microscopy in blue light of 450 mμ wave-length the maximum resolution with an optical system of numerical aperture 1.4 is 0.16 micron.

There is, in the near ultra-violet of the mercury-arc spectrum, a line of high intensity of 365 mμ wave-length, which can be isolated with a Wratten filter (No. 18A). In an optical system with a numerical aperture of 1.40 this radiation gives a maximum resolution of 0.13 micron. C. E. K. Mees pointed out that the difference between the resolution of 0.13 and 0.11 micron seems hardly sufficient justification for making the whole optical system of quartz with a complicated light source such as the condensed magnesium or cadmium spark, giving added trouble and expense, if nearly the same result could be obtained by an ordinary photomicrographic outfit, most optical glasses being probably transparent enough for 365 mμ wave-length radiation.

The possibility of such a practical application depends first of all on the transparency of the optical glass system. This was investigated by R. P. Loveland and the present writer with an ordinary semi-apochromat of 1.9 mm focal length, having the greatest thickness of glass of all achromatic microscope objectives. It was found that it is possible to get satisfactory short exposures even with the highest magnifications if a high intensity mercury arc is used. Such a

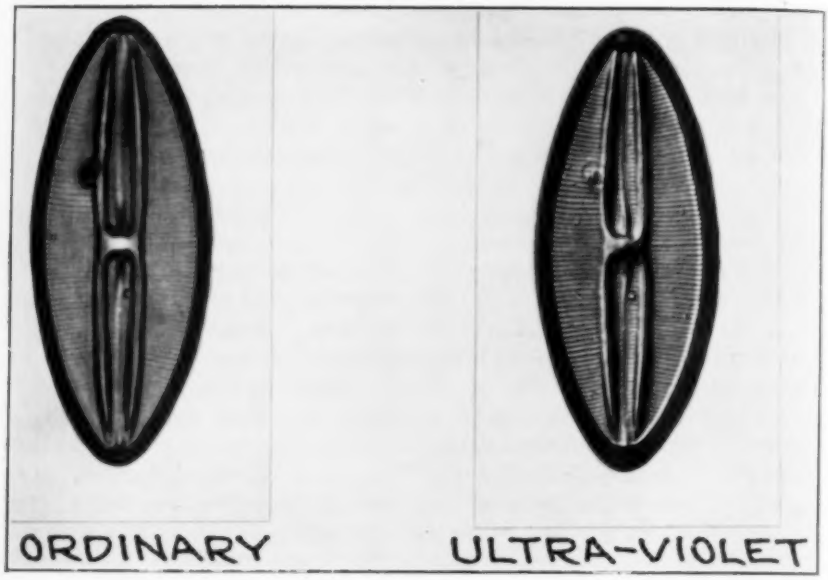
lamp was obtained from Kelvin, Bottomley and Baird, Ltd., London. It operates at normal atmospheric pressure, using a 200-volt direct current starting with 4.4 amperes and, after the arc is formed, automatically continues at 2.2 amperes. Under these conditions we were able to obtain photographs magnified 1,000 and 2,000 diameters in a few minutes. As was to be expected, however, the results showed the necessity of specially corrected objectives to secure the full effect of the 365 mμ wave-length radiation.

The work was continued in collaboration with Mr. L. V. Foster, of the Scientific Bureau of Bausch and Lomb Optical Company. The 365 mμ mercury-arc line is a doublet lying near another doublet of 366 mμ wave-length. Since the application of such a non-monochromatic light source precludes the use of von Rohr's monochromats, we had to limit ourselves to objectives of the achromatic type, which bring two spectral colors together into the same focus. This suggested a focusing method in the near ultra-violet as easy and simple as one in the visible light. The objectives are made to bring the 546 mμ green mercury-arc line to the same focus as the 365 mμ wave-length radiation, so that achromatism is accomplished for one wave-length in the visible and for one wave-length in the invisible spectrum. For the isolation of the green mercury line Wratten filter No. 77, which transmits 72 per cent. of the light, is used. Thus, by using this filter, it is possible to examine visually the preparation to be photographed, and focus, after which filter 18A, which transmits 38 per cent. of the 365 mμ radiation, is substituted and the exposure made. The result is a perfectly sharp picture revealing detail invisible to the eye.

Sandalwood oil was found to be the best immersion medium for transmitting 365 mμ wave-length and having the proper optical properties. The distance between an oil immersion objective and the cover-glass of the preparation is about 0.2 mm. In this thickness cedar oil absorbs 56 per cent. and sandalwood oil 32 per cent. of the ultra-violet radiation. Since a requirement for full resolution of objects is that the condenser aperture must equal the aperture of the objective, the condenser must have immersion contact with the slide. This contact may require a layer of oil from 0.2 mm upward. Should the total thickness of oil used between the condenser and the slide and between the cover-glass and the objective be as great as 1.0 mm, the absorption by cedar oil at 365 mμ would be 98.4 per cent. and for the same thickness the absorption by sandalwood oil would be 85 per cent. The transmission for cedar oil would be 1.6 per cent. and for sandalwood oil 14.4 per cent.; that is, the latter would be nearly ten times as transparent for this radiation as cedar oil. It can easily be seen that whichever oil is used it is well to keep the thickness of the oil layer between the condenser and slide at a minimum.

Most objects are mounted in Canada balsam, and only in special cases is realgar or another medium used. Several of these substances are too opaque for the 365 mμ wave-length. A convenient and quick method by which to determine roughly the absorption of the balsam is by the use of an x-ray screen of barium platinocyanide, which gives a bright green fluorescence when exposed to 365 mμ radiation. In the beam of the ultra-violet radiation the slide forms a shadow on the x-ray screen if the balsam absorbs the radiation.

The great advantage in the use of slides having Canada balsam as mountant is that it is already used to a great extent in microscopic research work necessitating fixing and staining. Such



A PHOTOGRAPH DEMONSTRATING THE ADVANTAGES OF ULTRA-VIOLET LIGHT

Navicula, PHOTOGRAPHED IN GREEN LIGHT AND IN ULTRA-VIOLET WITH WAVE-LENGTH 365 mμ TO SHOW THE DIFFERENCES IN RESOLVING POWER. 450×. 16 MM OBJECTIVE FROM BAUSCH AND LOMB WITH 15× HYPERPLANE EYEPIECE.

slides are useless for 275 mμ photomicrography, but very useful for 365 mμ photomicrography.

Very little is known concerning the absorption, in the ultra-violet, of the stains used in these slides. Mr. E. E. Richardson[1] determined their absorption spectra in 1 cm layer of solution, giving an approximate indication of what may be expected when a stain is used for ultra-violet photomicrography.

For the great majority of cases the Wratten M photographic plate is recommended for photomicrography. It is advisable in practice to employ the same photographic material as far as possible in order to reduce the number of variables to a minimum. A faster plate or film is preferable only with dark field illumination, very oblique illumination and with polarized light.

[1] Physics Department, Kodak Research Laboratories.

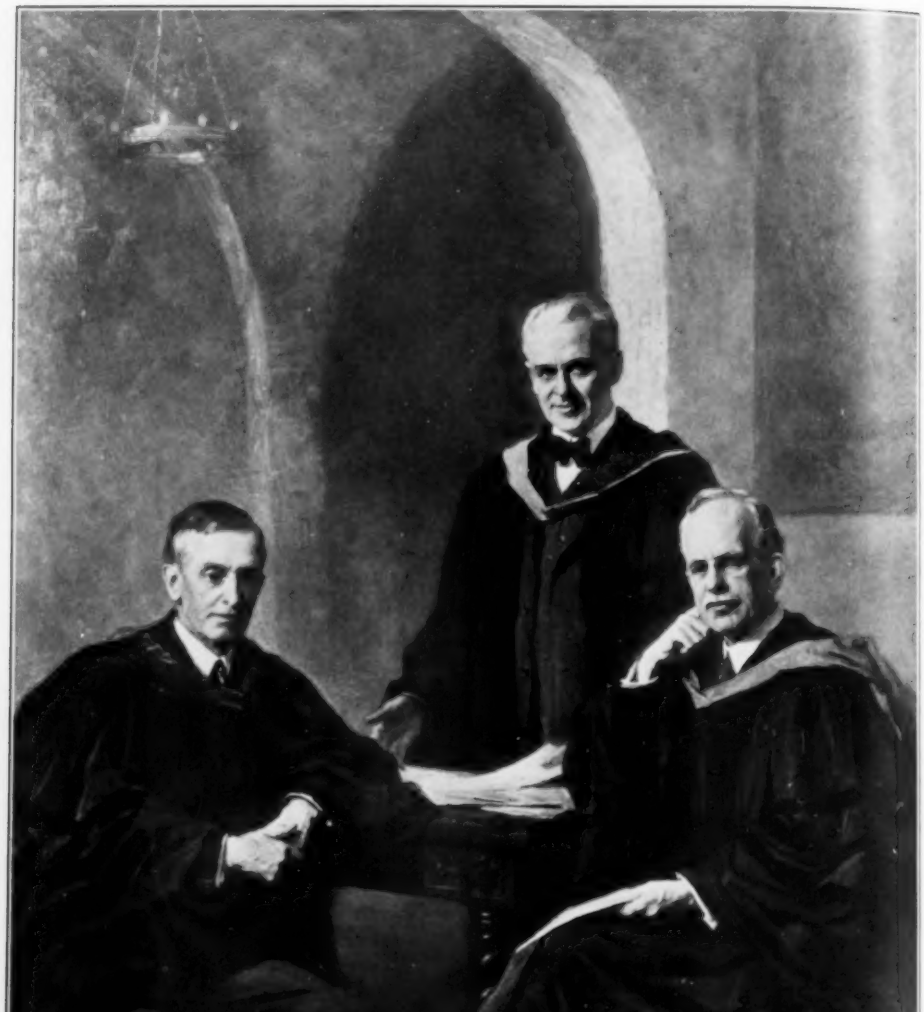
The new Wratten hypersensitive panchromatic plate has a higher speed in visible light than the Eastman Speedway plate, and is, therefore, very suitable for photomicrography in such light. With 365 mμ radiation, however, the Speedway plate is about three times faster than the Wratten hypersensitive panchromatic plate and should be used for 365 mμ photomicrography in extreme cases of low intensity, mentioned above.

Photomicrography with radiation of 365 mμ wave-length makes available nearly a 20 per cent. increase of resolving power, or alternatively, if the resolving power obtained with visible light is sufficient, the use of ultra-violet enables an increase of depth to be obtained by reduction of the aperture. The effect of increase of resolution is specially noticeable when using high power oculars. For instance, at ×500

magnification with a 16 mm objective of numerical aperture 0.25 a sharp image could hardly be obtained with a ×20 magnifying eyepiece. Under exactly the same optical conditions 365 mμ radiation will give quite sharp images.

The greatest advantage of this radiation, in comparison with visible light, lies in the absorption differences pronouncedly shown by the different proteins. Köhler pointed out many years ago that one advantage of the ultra-violet microscope lay in the fact that with it organic specimens can be differentiated in structure by virtue of the selective absorption which they manifest toward ultra-violet radiation. In order to bring out in visual microscopy differences in biological specimens and histological structure it is necessary to stain the subject studied. In many cases study must be made of material in the living condition to avoid changes induced by fixation, and in such cases ultra-violet micrography should be employed. Unstained specimens may be observed by means of the ultra-violet micrograph much as though they were stained. There are, however, two requirements for such application: ultra-violet light itself must not be injurious to the organisms studied and the organism must, to a certain extent, be transparent to ultra-violet radiation.

In this respect Köhler's ultra-violet micrography is quite different from ultra-violet micrography with 365 mμ radiation. There are a great number of biological specimens which are absolutely opaque for 275 mμ radiation and which show differentiation in 365 mμ radiation, just as there are a great number of histological specimens which are perfectly transparent for 365 mμ radiation and which show differentiation in 275 mμ radiation. Both 275 mμ and 365 mμ radiations, therefore, have their own field of application.



FOUNDERS OF THE CALIFORNIA INSTITUTE OF TECHNOLOGY FROM THE PAINTING IN THE ATHENEUM BY SEYMOUR THOMAS

THE PROGRESS OF SCIENCE

THE PASADENA MEETING OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

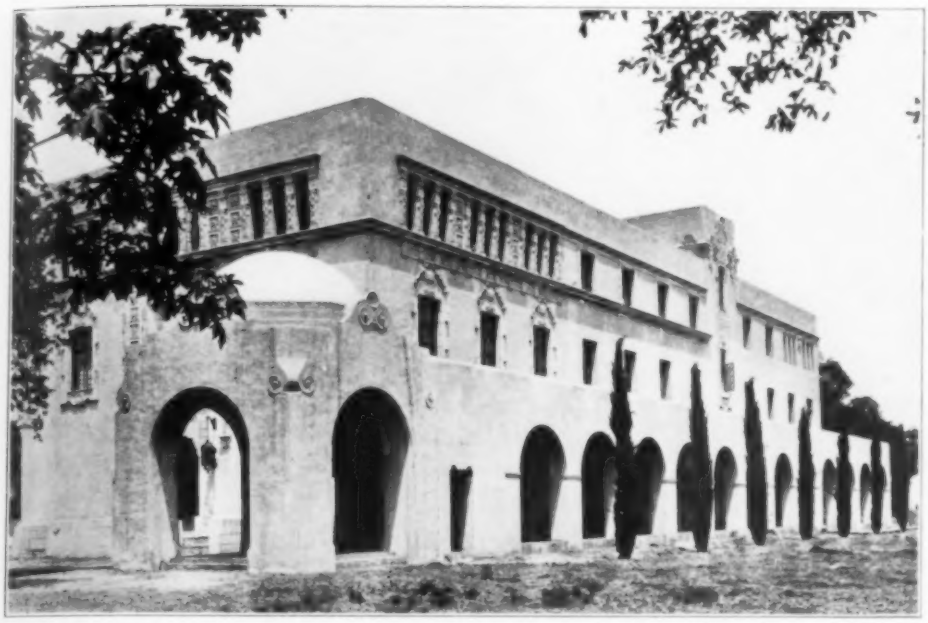
THE marked success of the eighty-eighth meeting of the American Association for the Advancement of Science—the first of the new series of national summer meetings—held in Pasadena and Los Angeles, California, from June 15 to 20, has apparently justified the association's new plan of holding annually, in addition to the winter meeting, a summer meeting of really national character. This success was due in part to the fact that the Pacific Division of the Association has for a number of years held very successful summer meetings on the Pacific Coast in which fifteen or more of the associated societies have regularly joined. The turning of this established convention into one of national character was therefore not difficult of accomplishment. All that was required was for the Pacific Division to withdraw temporarily, for the national officers actually to be present and to take charge, and for a goodly representation of Eastern members to attend.

All three of these requirements were successfully fulfilled. The officers of the Pacific Division very graciously retired in favor of the national officers while continuing to assist in every way possible in the details of arrangements and in coordinating the activities of the associated societies. The national president-elect, Dr. Franz Boas, attended the meeting at considerable personal sacrifice and gave one of the evening lectures which was an outstanding feature of the program. As Dr. Thomas Hunt Morgan, the retiring president, was already in Pasadena, both national presidents were in attendance, a precedent which the association will strive to follow in future summer meetings and which in itself gave a national aspect to the meeting. The representation from Eastern states and from foreign countries was much larger than had been expected and was also quite outstanding in personnel, national officers of the associated societies attending in many cases and contributing in a large way to the conduct of the program. The total attendance was nearly twice that at any preceding Pacific Division meeting.

A second reason for the very real success of the meeting was the nature of the program itself. Full accounts are being prepared by the permanent secretary of the association and will be published in an early issue of *Science*; nevertheless, it will perhaps be worth while to comment here upon the general success of the special features of the program inasmuch as they will undoubtedly set precedents for the conduct of future summer meetings.

The outstanding feature was unquestionably the large and unusually interesting group of special symposia and joint sessions with invited speakers. These covered a wide range of well-selected topics and were conducted by outstanding authorities in the various fields of science who in most cases had carefully coordinated their material. A unity which has often been lacking in the programs of the association was provided by making these symposia almost without exception joint sessions of two or more sections and their associated societies. This plan had the further advantage that the topics were treated

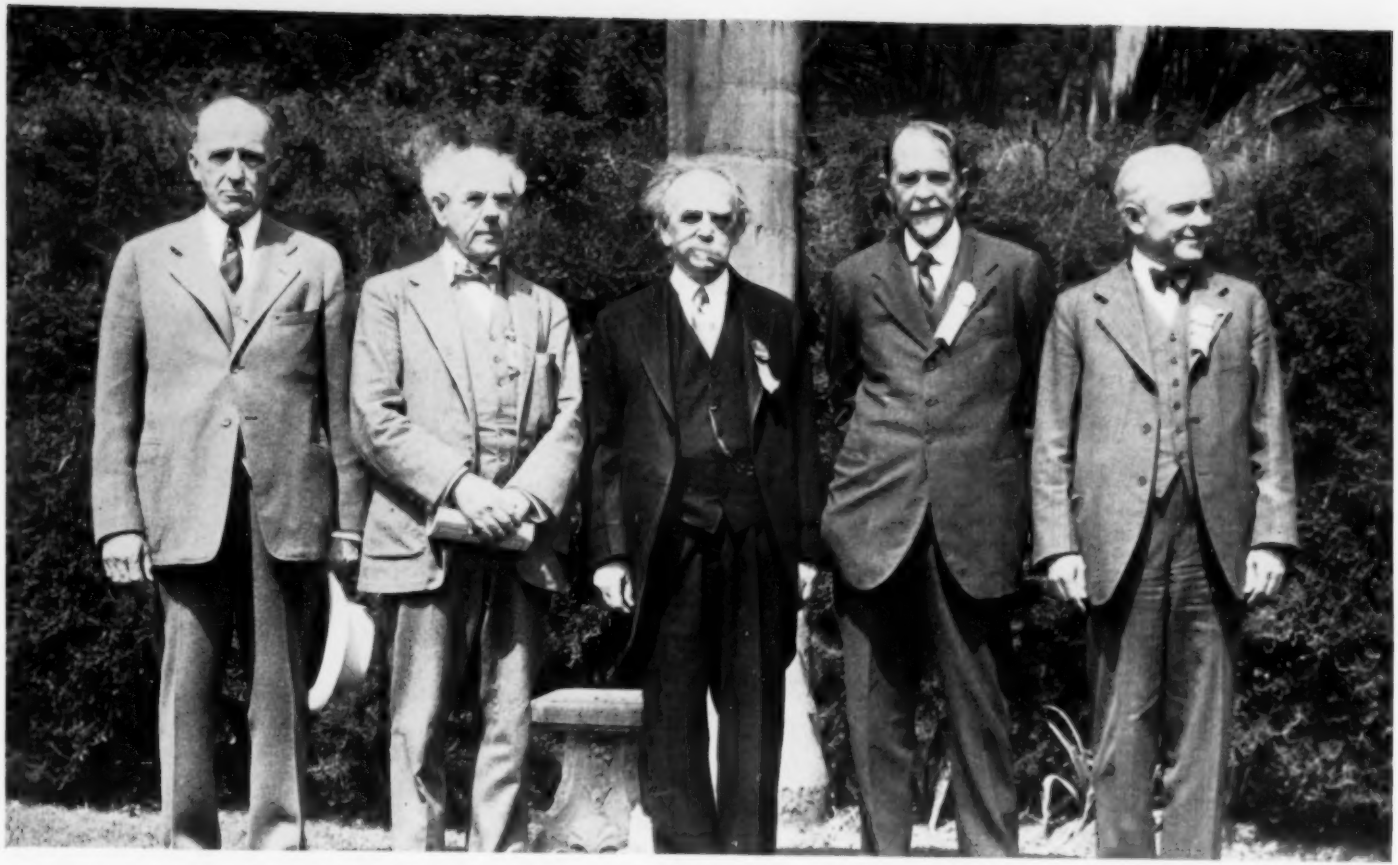
VIEW OF THE NORMAN BRIDGE LABORATORY OF PHYSICS



THE WILLIAM G. KERCKHOFF LABORATORIES OF THE BIOLOGICAL SCIENCES

from several view-points. Thus Dr. Boas suggested and arranged for a symposium on "The Antiquity of Man" with contributions by geologists, paleontologists and zoologists as well as anthropologists; and Dr. T. Wayland Vaughan, the president of the Pacific Division, planned and carried out a symposium on "The Major Problems of Modern Oceanographic Research," with four unusually well-selected papers and speakers dealing with the various physical, chemical, biological and geological aspects of the subject. At a joint session of the medical, biological and physical science groups, "High Voltage X-Ray Tubes and Their Medical and Biological Possibilities" were discussed. The engineering and geology sections held joint sessions on "The Colorado River Dam and Aqueduct" and on "Earthquakes and Earthquake Resisting Structures," as did the astronomy and physics groups on "The Present Status of the Problem of Nuclear Structure" and on certain astrophysical problems of common interest. The physicists and chemists united in a discussion of the "Quantum Mechanics of the Chemical Bond" and the chemists and biologists met together to consider various phases of "Photosynthesis and Photochemistry." These symposia were all of an exceedingly high caliber, and in more than one case literally every one in the world who had made important contributions to the subject was represented in the discussion.

The programs of the twenty-three associated societies which joined in the meeting were all excellent, many important scientific findings being announced for the first time, and the sessions were without exception well attended. Special mention should be made, however, of the interesting series of round table conferences carried out by the Pacific Coast Committee of the Social Science Research Council. Eight or ten such conferences on vital topics,



IN THE GROUNDS OF THE HENRY E. HUNTINGTON LIBRARY AND ART GALLERY

FROM LEFT TO RIGHT, DR. MAX FARRAND, DIRECTOR OF RESEARCH OF THE LIBRARY AND ART GALLERY; DR. J. MCKEEN CATTELL, CHAIRMAN OF THE EXECUTIVE COMMITTEE AND PAST PRESIDENT OF THE AMERICAN ASSOCIATION; PROFESSOR FRANZ BOAS, OF COLUMBIA UNIVERSITY, PRESIDENT OF THE ASSOCIATION; PROFESSOR THOMAS HUNT MORGAN, OF THE CALIFORNIA INSTITUTE OF TECHNOLOGY, RETIRING PRESIDENT; DR. ROBERT A. MILLIKAN, OF THE CALIFORNIA INSTITUTE OF TECHNOLOGY, WHO PRECEDED DR. MORGAN AS PRESIDENT.

DANIEL GUGGENHEIM AERONAUTICAL LABORATORY

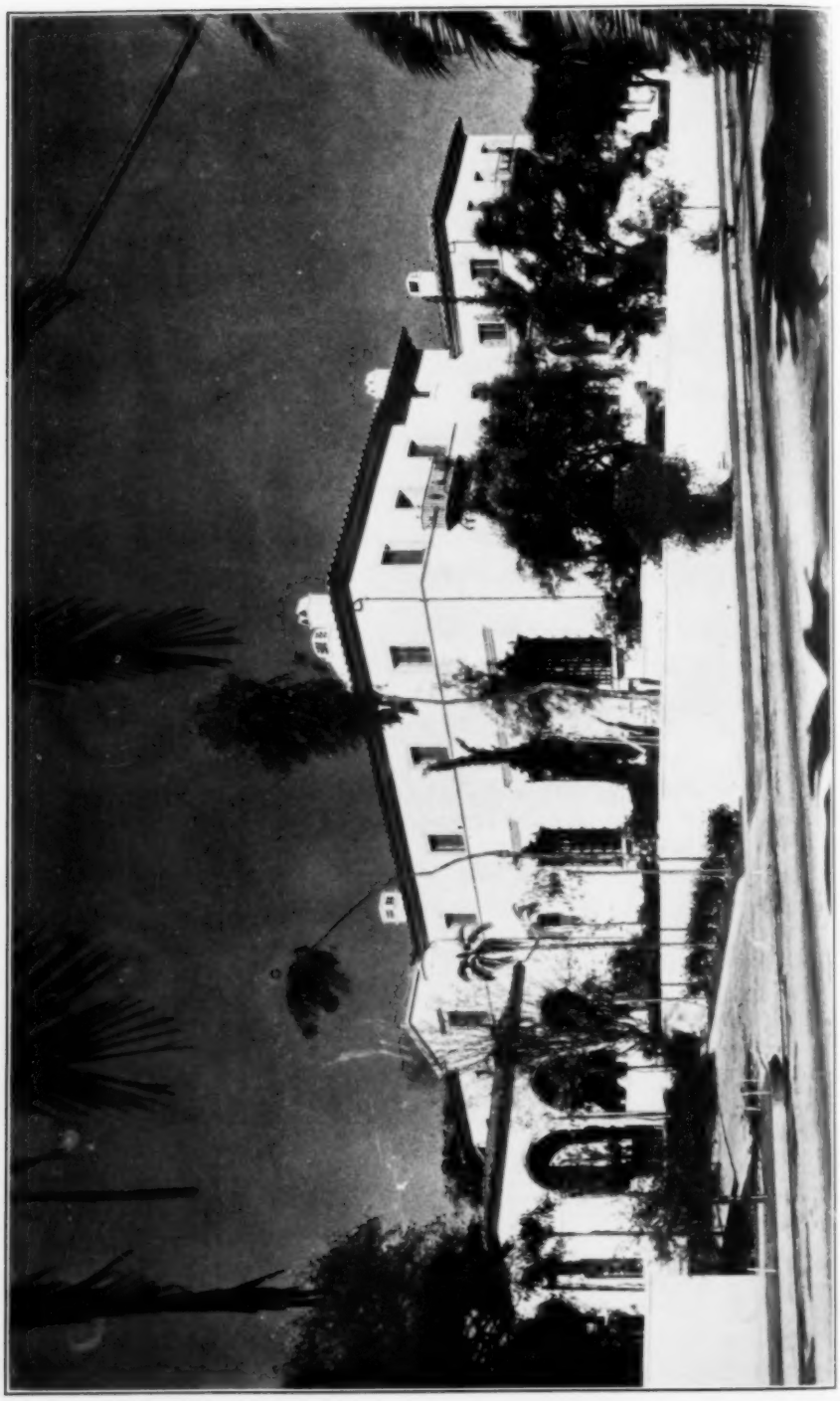
with well-qualified leaders, were held simultaneously and often led to spirited discussions. The method might well be tried by other societies as a variant on the usual type of scientific session.

The plan of concentrating the scientific sessions into the mornings in order to leave the afternoons free for excursions, social contacts, discussions and recreation apparently met with the approval of the majority of those attending the meeting. The opening reception in the gardens of the Huntington Library and Art Gallery set a delightful precedent for future summer meetings, and the interest in the other social and entertainment features of the meeting was much greater than had been anticipated. The numbers availing themselves of the various excursions which had been arranged, the attendance upon the scientific exhibits, demonstrations and inspections and the good spirits of the participants gave hearty approval of these features. The only criticism of the program which was voiced was that it was too full and interesting to allow sufficient time for discussion and for the full enjoyment of the social features which were available. Future summer meetings may well provide more leisure for discussion and social recreation.

The third feature of the meeting—the popular evening lectures—also received the hearty endorsement of all attending the convention. These included the address already mentioned of the president-elect of the association, Dr. Franz Boas, on "Race and Progress," an experimental lecture by Dr. H. D. Arnold on "Science Listens," a lecture by Dr. Arthur L. Day on "The Present Status of Seismology," an address by Dr. Charles A. Beard on "Scientists and History," and an illustrated lecture by Dr. Edwin P. Hubble on "The Realm of Nebulae." All were exceedingly well presented and were well received, not only by the members of the association, but also by a large and interested popular audience.

E. C. WATSON
CALIFORNIA INSTITUTE OF TECHNOLOGY

ERT A. MILLIKAN, OF THE CALIFORNIA INSTITUTE OF TECHNOLOGY, WHO PRECEDED DR. MORGAN AS PRESIDENT.



THE ATHENEUM

RESIDENCE HALL FOR VISITING PROFESSORS AND RESEARCH STUDENTS SERVING AS SOCIAL HEADQUARTERS FOR THE MEETING

APPRECIATION OF THE PASADENA MEETING BY THE DIRECTOR OF THE PRESS SERVICE

INCREASED appreciation of—or perhaps it should be said admiration for—the enthusiastic energy and constructive ability of the scientific men of California was the outstanding impression made upon the minds of the members of the Association by the Pasadena meeting.

From every point of view it was a very successful meeting. Both in planning the meeting and in carrying out the plans the local committee did its work in a most efficient manner so that there was no confusion.

The meeting was officially opened by a reception given through the courtesy of the director and trustees of the Huntington Library and Art Gallery in the gardens of the Huntington estate which was attended by almost a thousand members and guests of the Association. Dr. Max Farrand, director of research at the Library, presided and welcomed the Association on behalf of the institutions which served as hosts—the Huntington Library and Art Gallery, the California Institute of Technology and the Mt. Wilson Observatory of the Carnegie Institution of Washington.

Brief talks were given by Dr. Thomas H. Morgan, Dr. Franz Boas and Dr. Robert A. Millikan, after which refreshments were served, and the members were invited to inspect the treasures of the library and art gallery and the magnificent gardens. Perhaps the most interesting feature of the gardens is the wonderful collection of cacti, including hundreds of different kinds of these bizarre and exclusively American plants.

The popular addresses given at the general session were unusually interesting and diversified. The speakers were Dr. Franz Boas, president of the Association, Dr. H. D. Arnold, Dr. Arthur L. Day, Dr. Charles A. Beard, Dr. Maurice Holland and Dr. Edwin P. Hubble. The attendance on the five evenings was about 1,000, between 1,000 and 1,100, 700, 500 and 500. Probably if the Greek theater at Los Angeles, where the evening address were given, had been nearer Pasadena the attendance would have been somewhat larger.

No single spot in the entire United States is so admirably adapted to serve as a center for excursions of most varied interest both by motor and by plane as is Pasadena. Taking advantage of this fact, the local committee arranged for no less than twenty-three excursions which were greatly appreciated and well attended.

The research exhibits were more numerous and varied than heretofore, and attracted much attention. One of the most popular and interesting was a representative collection of living reptiles from the southwestern states, including many different kinds of rattlesnakes.

Of the more strictly formal portion of the program, the arrangement of numerous symposia in many different fields of science was the outstanding feature. While it is difficult fairly to compare these symposia one with another, it is probably safe to say that the symposium on quantum mechanics and the chemical bond in which the three outstanding workers in that particular field, all very young men, participated, was the most significant.

The number of formal and informal papers presented was 538, distributed as follows: mathematics, 3; physics, 80; chemistry, 57; astronomy, 33; geology and geography (including oceanography and seismology), 36; zoology, 85; botany, 59; anthropology, 21; social and economic science, 64; engineering, 6; medical science, 66; agriculture, 20, and education, 16.

The subject matter in the papers was of an exceptionally high standard.

THE ATHENEUM
RESIDENCE HALL FOR VISITING PROFESSORS AND RESEARCH STUDENTS SERVING AS SOCIAL HEADQUARTERS FOR THE MEETING

DABNEY HALL OF THE HUMANITIES

Many of the papers included entirely new material, while in many others a new light was brought to bear on subjects as yet not wholly clear. The proportion of papers written in plain and simple language was larger than at any previous meeting. The natural result of this was that the meeting received an unexpected amount of attention in the press, some of the eastern dailies reporting it more fully than they had reported the Cleveland meeting.

Of the papers presented twenty-three per cent. dealt with subjects concerning the Pacific states, while three per cent. dealt with subjects concerning regions beyond the borders of the continental United States, chiefly Hawaii.

In view of the altogether exceptional interest attaching to the geology, the fauna and the flora of the Pacific and the Mountain states, and to the oceanographic conditions along and off the Pacific coast, a much greater percentage of papers of local interest would have been anticipated. But especially within the past decade there has been a marked broadening in the American scientific outlook so that now although papers may be primarily based upon data gathered locally the broad application of the results brought out in any investigation are considered in their presentation.

The constant increase in the proportion of papers of broad general interest presented at the meetings of the association is bringing about a more clearly marked division of the scientific field, and is pointing out the way for a closer cooperation between the association and local academies and societies.

The total registration at the meeting was about 1,200, but there were probably about 1,500 in actual attendance.

Fully appreciative of the fact that the success of its meetings is directly proportionate to the energy displayed by the local committees in preparing for them, the association feels that it owes a debt of gratitude to the scientific men of California for making the somewhat experimental first regular summer meeting such a notable success.

AUSTIN H. CLARK

DR. L. O. HOWARD AND THE CAPPER AWARD

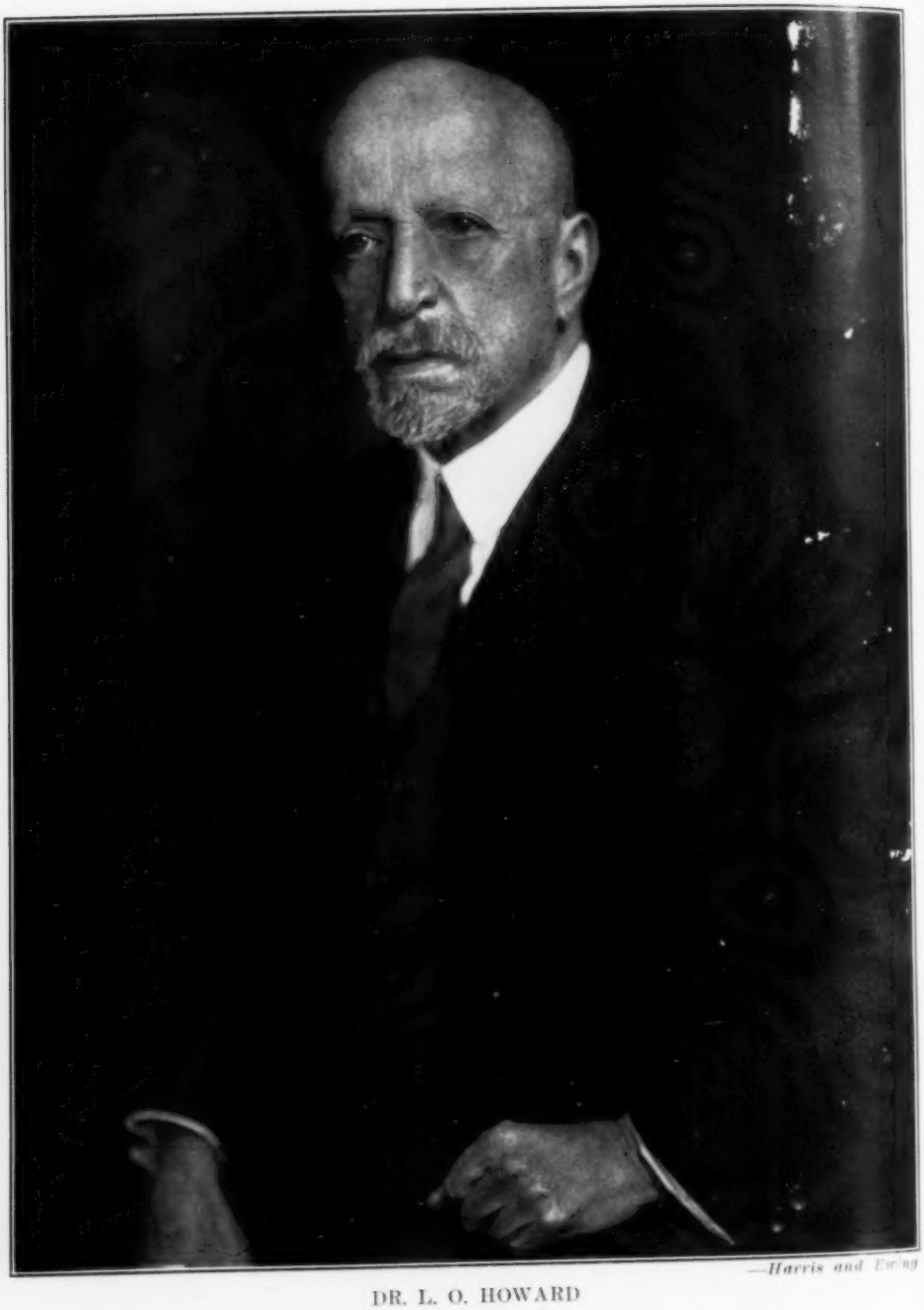
In the fall of 1878, a young graduate of Cornell University who had just attained his majority went with mingled feelings of wonder and enthusiasm to the city of Washington in response to a call from the United States Department of Agriculture. This young man had prepared at college for medicine but incidentally had become interested in entomology and had even pursued graduate study in that science. Therefore, when C. V. Riley, chief entomologist of the United States Department of Agriculture, applied to Professor J. H. Comstock for an office assistant, the latter recommended the young man in question who has since become familiar to all of us as Dr. L. O. Howard. What a happy combination of training, this medical preparatory work mingled with a study of the insect world; and how significant this intimate sympathy with the health of human individuals became in the later work of this able man.

To his disappointment, young Howard was employed at first simply as a clerk, but gradually, as matters developed, he was put at entomological work; and how enthusiastically he followed it. Not long ago in speaking of this period he said: "We were all young—it is surprising now to think how young we were! Trelease and I were 22, Mrs. Comstock was 25 and Comstock was only 30. We were filled with the enthusiasm of youth, worked hard and were delighted with the interesting and important discoveries we made." Thus early was set the stage for the work of a man in a field of scientific endeavor that ever accrued to the benefit of mankind.

Dr. Howard's earlier studies, which became particularly significant in his later work, were with the tiny hymenopterous parasites of scale insects. These studies not only led to his becoming a recognized authority on these minute insects but they undoubtedly impressed him with the importance of the rôle of parasites in checking the increase of insect pests. The trend of his thought in this direction was probably greatly accelerated and augmented by the success in the control of the cottony cushion scale in California through the introduction of the Australian ladybird.

No one plant or animal can long maintain the ascendancy over the other plants and animals on the earth. If one species increases abnormally for a time, it will eventually reach its height in numbers and then slowly or perhaps swiftly recede to its normal status. Such a phenomenon happens again and again in the insect world. Careful, extended studies by Howard, Tothill and others have shown that fluctuations in the population of an insect species are usually correlated with the scarcity and abundance of its natural enemies. Apparently, the sound, logical step to be taken in the ultimate, permanent control of an insect, especially an introduced pest, is to breed its natural enemies artificially and to distribute them throughout the range of the pest. Dr. Howard early realized the fundamental character of this natural control of insects and with the prescience of a forward-looking mind he organized and developed a program for the introduction and distribution of the natural enemies of the gipsy and brown-tail moths in New England on a scale never before conceived or attempted. The success attending this fruitful experiment led him to organize similar efforts at control in the case of other notable pests.

His remarkable work in the utilization of the natural enemies of insects in the control of injurious species has been the standard and inspiration for all similar work in this and in other countries. Unquestionably it stands as one of his notable contributions to the



—Harris and Ewing

DR. L. O. HOWARD

amelioration of the untoward conditions of agriculture in this country. No single idea at any time, however, has claimed all his attention. His was not a "single-track mind."

Dr. Howard had early been interested in mosquitoes and had early made a practical suggestion for their control although the use of oil on water was not original with him. His interest in mosquitoes had led him to ponder earnestly the early theory propounded by Dr. Carlos Finlay that these insects were responsible for the transfer of yellow fever from one human to another. The idea awakened and intensified his interest in the possible vital relations of common household insects to the welfare of man and kept him on the *qui vive* for possible developments. Later, in 1900, when the classic experiments of Reed, Carroll, Agramonte and Lazear demonstrated the intimate relation between the "Stegomyia" mosquito and yellow fever, Dr. Howard began in earnest his great work in educating all of us in the vital relations of insects to health. His extended studies on mosquitoes and the housefly, supplemented by his public lectures, timely articles, extended bulletins, and finally, his two books, "Mosquitoes; how they live; how they carry disease; how they are classified; how they may be destroyed" and "The Housefly, disease carrier," aroused the people of this country to the danger arising from close association with certain common insects. In the opinion of the writer this work of Dr. Howard constitutes another of his outstanding contributions to the welfare of the rural population of this country, for typhoid fever and malaria, at least, are distinctively rural diseases.

Granting that the tiny but innumerable animals we group together as insects are a constantly increasing and unrelenting menace to mankind and should be unceasingly fought with our most skillful methods, then Dr. Howard, of all men, has organized, developed and directed the greatest agency in the history of the science of entomology for carrying on the fight. For over thirty years he was chief of the Bureau of Entomology, and its present efficient organization is due to his far-sightedness, his skill as an organizer and his calm but forceful ability as an administrator. We believe his success as an administrator has come from his ability as a leader rather than from any quality he may have had as a driver. Dr. Howard early became national minded in his work as chief of the bureau. A little pamphlet entitled "Directory of Field Activities of the Bureau of Entomology," classified as Miscellaneous Publication No. 83 of the United States Department of Agriculture, Bureau of Entomology, speaks more eloquently than can the writer of the broad and extensive work in entomology developed by Dr. Howard. A superficial perusal of this tiny booklet will show that the Bureau of Entomology has established one or more field laboratories for the study of insect pests in every state of the Union with the possible exception of New Hampshire, Vermont and Minnesota. This evidence alone without further elaboration on the published results of the investigations carried on in these numerous laboratories attests the great work in the interests of agriculture performed by Dr. Howard. Perhaps after all, this direct service to agriculturists in the practical and effective solution of their problems in insect control will be considered his greatest contribution to the advance of agriculture in this country.

The writer can not close without emphasizing the internationally minded character of Dr. Howard. No man in this country has a wider, more intimate acquaintance with the entomologists of the world than has Dr. Howard. He has cultivated the acquaintance of these men not alone because of the ideas and suggestions that he might glean from them but that he might also render like

service in return; and it is with a feeling of profound satisfaction that the writer is able to record the shipments of natural enemies of insects of this country by Dr. Howard to various foreign countries to aid the authorities in bringing insect pests of those localities under control.

Every individual in this country and the many in foreign countries who know Dr. Howard and are familiar with his work are not only gratified that he has received the Capper Award but are sure that it has been most deservedly bestowed.

GLENN W. HERRICK
CORNELL UNIVERSITY

THE CAPPER AWARD

MY object in establishing The Capper Award for Distinguished Service to American Agriculture was to provide a concrete expression of gratitude to some of the people who make contributions of national importance to American agriculture and to assist in stimulating public appreciation of unusually fine service to our basic industry. The award consists of a gold medal and $5,000 in cash, and is made annually.

The project is completely in charge of a committee of seven men: James T. Jardine, chief of the Office of Experiment Stations, United States Department of Agriculture; Carl R. Gray, president of the Union Pacific Railroad System; Dr. John H. Finley, editor of the New York *Times;* Dr. Walter T. Swingle, plant physiologist and agricultural explorer, United States Department of Agriculture; Dr. H. A. Morgan, president of the University of Tennessee; Alexander Legge, president of the International Harvester Company, and F. D. Farrell, president of the Kansas State College. F. B. Nichols, the managing editor of my farm papers, is secretary of the committee, and all correspondence concerning the award should be addressed to him at the Capper Building, Topeka, Kan.

It is made in accordance with five simple rules, as follows:

1. The award will consist of a gold medal and $5,000 in cash.

2. Any living American who has rendered distinguished service to the agriculture of the United States is eligible for consideration.

3. No time limit is imposed as to when the service rendered to agriculture was performed.

4. The award will be made annually.

5. No person who has received the award will be eligible to receive it again.

The first award, made in 1930, was given to Dr. S. M. Babcock, of the University of Wisconsin, in recognition of his epoch-making invention of the world-famous "Babcock Test" for butterfat and for his numerous other less widely known scientific contributions to the welfare of agriculture, and especially the dairy industry. Dr. L. O. Howard, former chief of the Bureau of Entomology of the United States Department of Agriculture, will receive the award of 1931, for his work in entomology, and especially for his efforts in the biological control of insects.

About 200 persons were nominated for the award last year, some by as many as 175 different individuals. Apparently this indicates a considerable interest in this project. It is my hope that this award will serve as a source of real inspiration for some of the younger men in agricultural work, in encouraging them to put forth their maximum efforts in the development of our basic industry. In any case I have been much gratified by the general approval which has been given to the two awards which have been made. As the project develops from year to year I hope we can continue in our selections to merit the commendation of the scientific world.

ARTHUR CAPPER
U. S. SENATE